POWER

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The Power Show

THE third Power Show, as it is popularly known, or more formally the National Exposition of Power and Mechanical Engineering, is being held at the Grand Central Palace in New York this week.

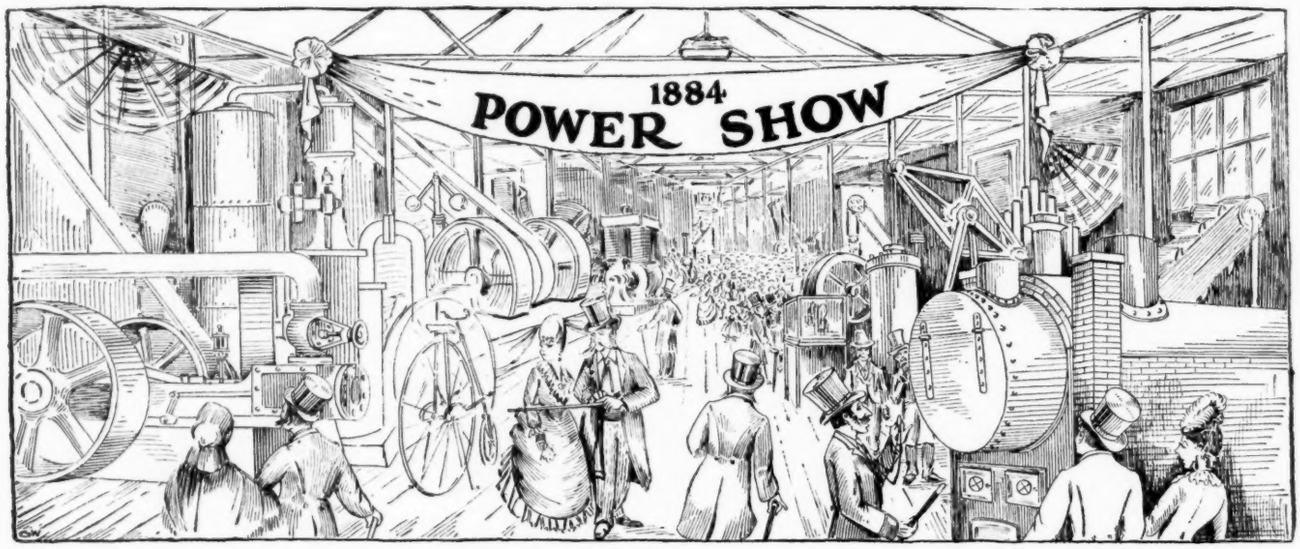
Suggested and inspired by Mr. E. G. Bailey, this undertaking has been successful from the start, each annual exposition exceeding its predecessor in number and variety of exhibits and in the number of and interest displayed by its visitors.

Held at the same time as the meetings of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers, it provides an additional feature for the visit to New York of their members, and the presence in the city of so large and important a representation of the engineering profession assures an appreciative audience and desirable contacts for the exhibitors.

In this issue we have attempted to recall what similar exhibitions were like when *Power* was started forty years ago, to outline some of the outstanding developments in power-plant apparatus and methods during those two-score years and in an article by Mr. W. L. Abbott to outline the changes that have been necessary in the qualifications of the men to whom the operation of this apparatus, enormously increased in unit capacity and in complexity, is intrusted.

May the success and the satisfaction of the past two years be repeated, and may the Power Show become and continue to be an annual exponent of progress made in the methods of producing and transmitting power and the machinery, apparatus, and materials employed.

F. R. Low



The Power Exhibition of 1884

The development in power-plant equipment since the founding of "Power" in 1884 has been startling. Most of this work has been along the lines of improving methods and equipment in existence at that time. This is brought out in the following improvised story of what a power show in 1884 would have covered.

THOSE ENGINEERS who are able to do so, should visit the Power Exhibition now being held in New York City. Here are shown hundreds of appliances for the power house, including steam engines running under steam, boilers set up ready for firing,

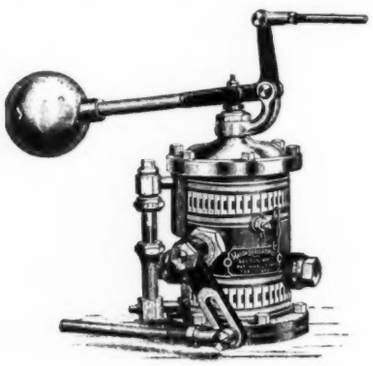


Fig. 1—Mason governor to regulate pump speed

new furnaces, condensers, valves, transmission, models of cable and electric street cars, and most interesting of all, a new steam engine, the Parsons turbine, and a system whereby a second fluid is used in the plant along with steam as a heat medium.

While by no means the feature most interesting from the scientific point of view, the number of exhibitions of steam engines is astonishing. It almost seems that there are too many firms engaged in engine building for the factories of the country to absorb all their output. But as pointed out by an eminent engineer who accompanied the reporter in his round of the exhibition, the growth of the country largely depends upon the availability of steam power. In former days the location of a factory was determined by the availability of a water power, and this caused manufacturing to be centered in New England, this section possessing most of the water-power sites. Where factories were erected away from water, the high cost of the efficient steam engines and the poor economy of the cheaper units were serious factors in meeting competitive prices.

The advent of the automatic-governor, high-speed engine of small powers should do much to decentralize the industries of the country. While there are a number of engines on exhibit such as the Harris-Corliss, Fig. 7, having Corliss valves, the majority are equipped with some form of slide, gridiron or piston valve. The most interesting of these engines is the Straight Line, designed by Professor Sweet and shown in Fig. 4.

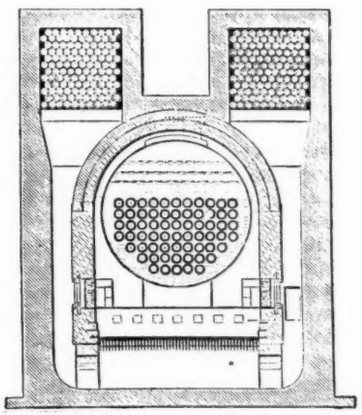


Fig. 2—Furnace air preheated by flue gas

This unit is so constructed that the framing tieing the cylinder to the bearing is in straight tension and compression. The flywheels, of which there are two, are mounted one on each side of the crank and between the main bearings. The valve used is the Sweet double-ported balance type, wherein a cover or pressure plate

Prime Movers of 1884

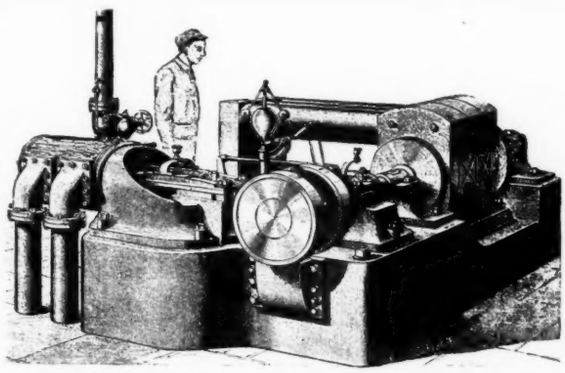


Fig. 3—Edison dynamo coupled to engine

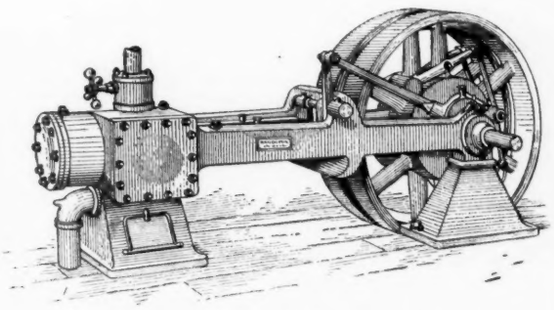


Fig. 4—Straight-line engine

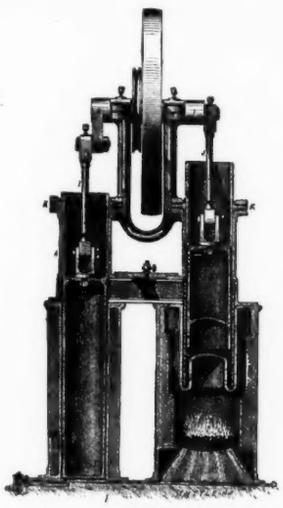


Fig. 5—Rider hot-air engine

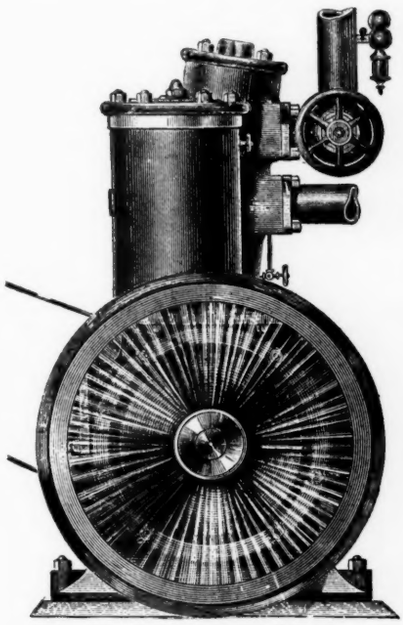


Fig. 6 (above)—Westinghouse single-acting engine

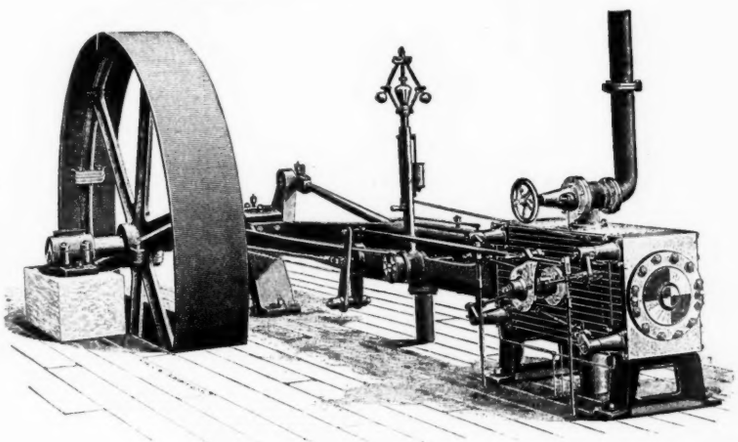


Fig. 7 (left)—Harris-Corliss engine

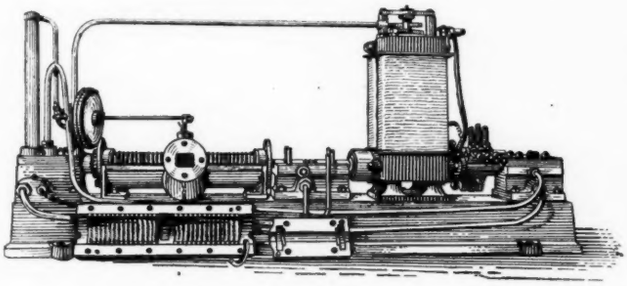


Fig. 8—Parsons steam turbine

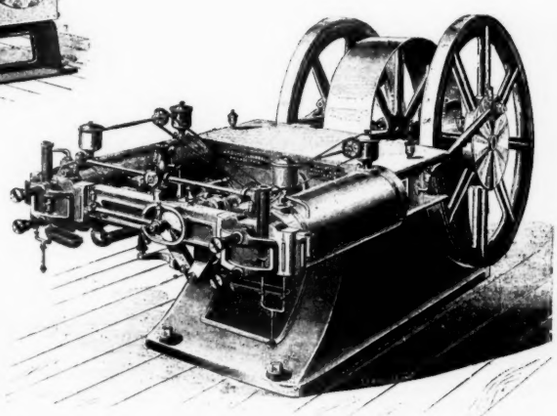


Fig. 9—Engine using natural gas

is placed over the valve and, being supported by side rails, takes all the pressure from the top of the valve.

The use of live-steam coils in the receiver of compound engines to dry out the steam going to the low-pressure cylinder is not new. One engineering company accomplishes this drying process by waste heat. This is done by running the high-pressure cylinder exhaust

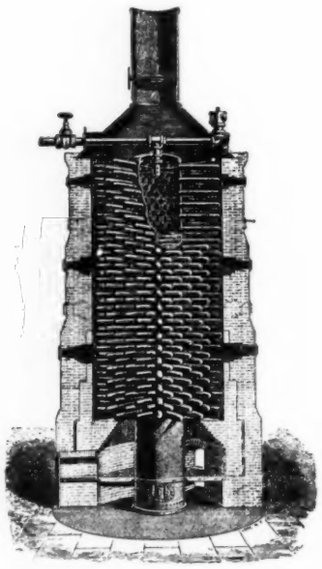


Fig. 10—Porcupine boiler

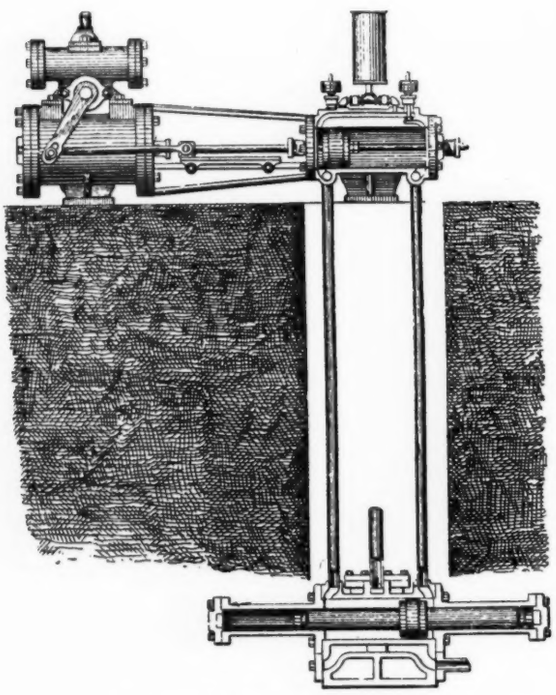


Fig. 11—Hydraulic power system

line through the boiler smokebox or breeching, and the chimney gases, which are around 500 deg. F., not only dry the steam but also superheat it to some extent. The system is shown in Fig. 15.

A unique exhibit is an engine built by an Englishman, Charles Parsons, and which is called a "steam turbine." In this, Fig. 8, there are a number of rows of tiny blades upon which the steam strikes and forces the drum carrying these blades to revolve. Between each set of revolving blades is placed a set of stationary ones which direct the steam into the next set of revolving blades. The model of six horsepower drives a small electric dynamo, and its speed is governed by the voltage developed in the dynamo. The exhibitor claims that this machine can be built as large as the largest steam engine and would use no more steam. The main advantage of the new engine is the matter of first cost, for evidently it weighs but a fraction of the weight of a reciprocating engine.

A number of years ago someone suggested the use of a second fluid in the steam plant. This has led to the invention of what is called a binary system; in this the steam, after doing work in the engine, is exhausted into the furnace of a boiler filled with carbon bisulphide, which takes up some of the heat in the steam and forms a vapor which is expanded in a second cylinder and then condensed. In this way more work is done per pound of fluid than with steam alone.

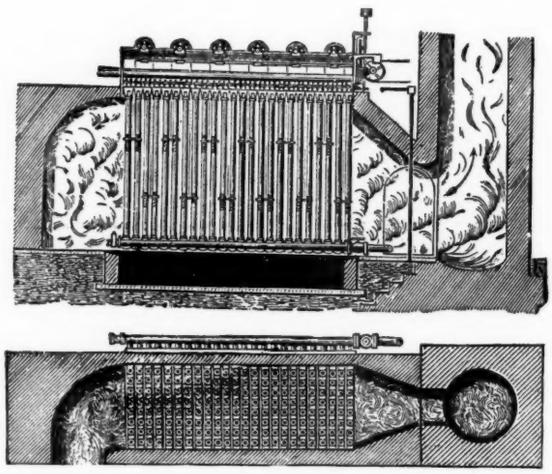


Fig. 12—Economizer recovers heat in flue gases

Still another interesting machine is a "gas" engine in which, after gas and air are introduced into the cylinder, the flywheel and crank forces the piston into the cylinder, compressing the gas and air to about 40 lb. per sq.in. This has been found to be an improvement over the "free-piston" gas engine. While just introduced into this country, it is claimed that many are in use in Europe. The representative, in answer to an inquiry, said that either natural or artificial gas could be used. This should find a large market in the Pennsylvania natural-gas fields or in shops too small to use a steam engine. A twin-cylinder unit is shown in Fig. 9.

While the flue (horizontal-tubular) boiler is more generally represented, there are models of two water-tube boilers. These boilers are made up of a series of tubes connected to end headers which have their upper ends opening into a drum. Water fills the tubes, headers and part of the drum. The furnace is under the tubes, and the gases are forced to travel along and up through the tubes by firebrick partitions.

The boilers on exhibit are all, with one exception, built for pressures of around 75 lb. gage. This repre-

sents a considerable advance over the 40 to 50 lb. pressure carried in most of the present-day plants. That pressures will ultimately go beyond 75 lb. is indicated by the presence of a water-tube boiler built for 400 lb.; this is a model of a boiler designed for a high-speed steamship.

Wet steam, as many engineers have pointed out, increases the steam consumption of an engine very rapidly. To dry out the steam before it leaves the boiler, many of the horizontal type are equipped with steam domes, the idea being that the water will settle out of the steam before leaving the drum. One exhibitor has his boiler equipped with a pipe passing through the smokebox at the boiler front. Steam from the drum is dried out as it flows along the pipe to the engine. This system seems to possess considerable value.

Still another feature in boiler building is worthy of mention. It has been customary for boilermakers to use a number of sheets to form the shell of the boiler. Steel mills are now able to roll much wider sheets, and

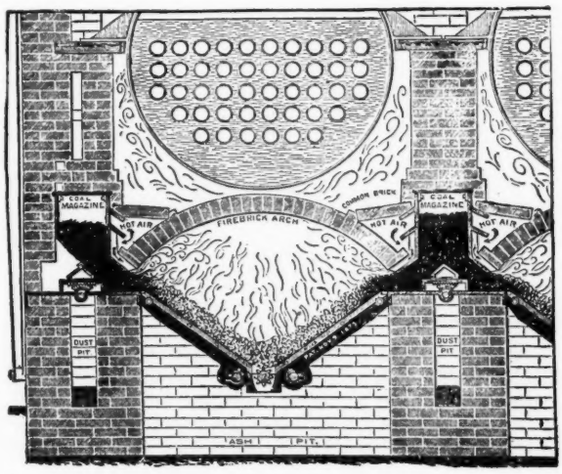


Fig. 13—Murphy stoker

the tendency is toward the general use of but one sheet for the boiler shell, the row of rivets being above the brickwork line.

It has been the claim of many that there is a large loss of heat in a boiler furnace by reason of heat radiation through the brick walls. One furnace shown goes far toward the recovery of this radiant heat by having a series of water tubes along the sides of the furnace and connected to the water spaces of the boiler.

While coal and labor are too cheap to justify any large investment in special firing equipment, the objection to smoking chimneys in residential districts will create a demand for automatic firing methods. Among the apparatus offered are a number of smoke consumers. In one of these part of the chimney gases are reintroduced into the furnace to be reburned. Since the gases passing out of the boiler carry a large percentage of unburned air, the re-use of this hot air not only assists in the combustion in the furnace, but insures a higher furnace temperature. In fact, it is as much of an air preheater as it is a smoke consumer.

The question of the economy of preheaters for stationary boilers is still unsettled. So little does its saving of coal amount to in dollars and cents that its adoption has been slow. On shipboard the forcing of the boilers are so necessary that forced draft is universal. The Howden system, of which a model is shown, covers not only a forced draft but likewise an air preheater. Two arrangements are in use. In one a helical flange is riveted around the sheet of a Scotch marine boiler and a second sheet wrapped around the flange. Air for the furnace is then drawn from between the

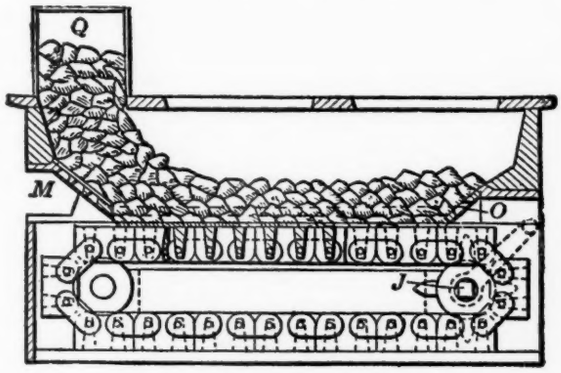


Fig. 14—Weller stoker

two shells, the helical flange forcing the air in a spiral path. The advantage most noticeable on shipboard is the cooler boiler room. The second design embodies a set of pipes placed in a frame at the entrance to the stack. The hot gases passing up, heat the air flowing through the pipes on the way to the furnace. Since the furnace temperature is somewhat chilled by the cold furnace walls, the preheating should be of advantage. This design appears in Fig. 2.

Still a second apparatus to recover part of the heat in the stack gases is an "economizer," Fig. 12. This consists of two headers into which tubes are driven with a taper fit. The feed water on its way to the boiler is passed through these tubes, while the hot chimney gases, in passing between the rows of tubes, heat up the water.

While the steam admitted to an engine is automatically regulated to meet partly the demands on the engine, the supply of water fed to the boiler is usually controlled by the fireman. As a result there may be too little or too much water going to the boiler. Regulators are by no means new, but the number shown indicates that it is becoming a practice to equip the boiler with a feed-water regulator that will supply water in accordance with the amount in the boiler, and a damper regulator by which the stack damper is opened or closed as the steam pressure falls or rises. Evi-

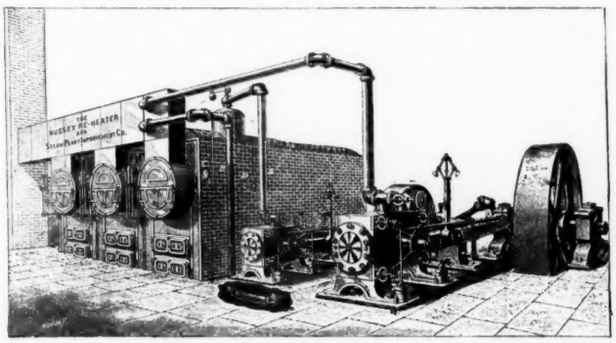


Fig. 15—Steam to low-pressure cylinder reheated by flue gases in Hussey system

dently, the time is coming when the coal fed into the furnace will be regulated by the steam demand, as will likewise the rate of burning and the rate of boiler feed.

In stokers two general types are shown. One covers an inclined grate, Fig. 13, upon which coal is fed from either side of the furnace. This, the Murphy, is a purely American design. A second design, Fig. 14, is that covered by the Weller stoker, which consists of a series of grate bars fastened on an endless chain. These grates are in a frame and are placed in the furnace. Coal is fed onto the grates, and as the chain travels toward the bridge wall, the coal is moved along so that when dumped at the bridge wall the fuel is entirely consumed.

One most interesting instrument is a spectroscope, which consists of a set of spectacles with colored glasses. By looking through these glasses into the

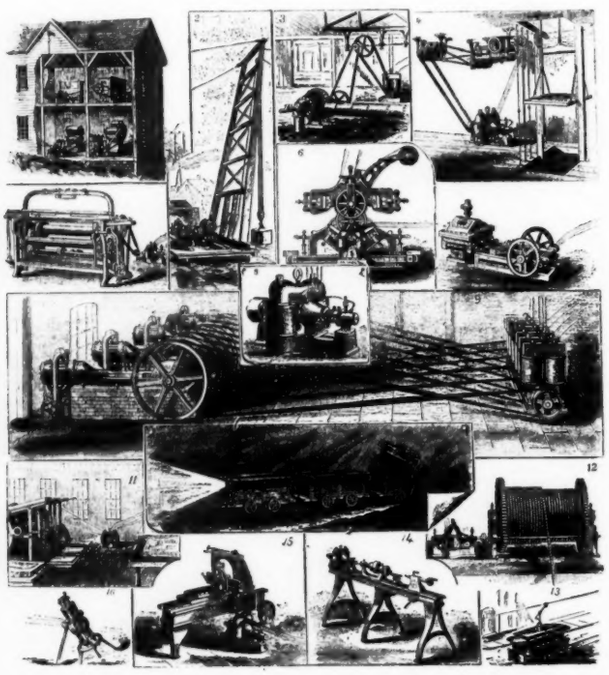


Fig. 16—Sprague electric system

furnace, the temperature of the flames and the condition of the fire bed are readily ascertained.

Several firms are showing steam-engine indicators, the price being well within the reach of any engineer.

The question of a power supply for shops too small to have engine rooms is a very live one. Three systems, as outlined by drawings and models on exhibit, are suggested. As to which will be adopted only the future can tell. One exhibitor has a drawing of a hydraulic system, Fig. 11. This contemplates the running of water pipes through the streets, and each customer has a duplex hydraulic motor which is driven by water supplied by a central pumping station. The displacement of the water in one end of the pump moves the plunger of the motor and upon reversal of the pump the motor ram is again moved by the water from the second end of the pump. Another contemplates the supplying of steam from a central boiler plant, the shops to be equipped with engines of a size suitable for their needs. This is but an expansion of the district steam-heating system, such as the one in New York City, which has several hundred customers, the charge being 50 cents per 1,000 lb. of steam at 60 lb. gage pressure. The third and most novel is the electric system. At present the electric-light plants supply only lighting, but one manufacturer of dynamos proposes to build small motors, similar to dynamos but running backward, and electric energy will be supplied by the lighting company over wires to the motors in the user's premises. This, if it can be done economically, should have possibilities, for at present the light plants are run only in the night time. The use of the light plant for power during the day is practiced by one company at the present time. This plant is located under a shoe shop, and during the day the engine drives the shoe machinery by a belt. A direct-connected Edison electric dynamo is shown in Fig. 3.

The Sprague system of electric distribution of power shows the application of motors to machines and mills. Fig. 16 shows this system. Picture 1, is of a flour mill; 2, hoist for building purposes; 3, turbine driving generator; 4, elevator; 5, loom; 6, calico-printing machine; 7, mining pump; 8, the motor; 9, central station; 10, mine tramway; 11, printing press; 12, mine hoist; 13, street car; 14, wood lathe; 15, metal planer; 16, mining drill.

A still more unusual invention is an ice machine. This is for the purpose of making artificial ice to be used in place of natural ice. While it is new and even the exhibitor was rather vague in explaining how it worked, apparently a volatile liquid is allowed to expand into a receptacle and in so doing is greatly reduced in temperature, sufficiently to freeze water flowing over the side of the receptacle. The vapor is then drawn into a compressor and raised to the original pressure, whereupon the vapor is condensed by the application of water at ordinary temperature.

The Mason regulator takes its motion direct from the piston rod of the pump or engine, and is connected directly with a balanced valve placed in the steam pipe. This is shown in Fig. 1.

The Rider hot-air engine, shown in Fig. 5, has been in use for some time for pumping purposes for railroad water tanks, manufactories, stables, private houses, etc., where a light power and one that demands little attendance is required.

News that the Westinghouse Machine Co. has been enlarging its works to a four engine per working day capacity indicates the popularity of this engine, which can be had in sizes of from 4 to 75 hp. A picture of this engine is shown in Fig. 6.

A familiar sight is the exhibit of the porcupine boiler, shown in Fig. 10. The essential feature is a vertical drum with radial tubes. The inner end of each tube is open, while the outer end is closed. The inner ends of tubes are expanded into the holes in the drum. The steam leaves the boiler through a vertical nipple, in the upper end of the drum, from which a series of small horizontal pipes extend outwardly and into the uppermost radial tubes. By this means steam is made to pass out in the large tube to the outer end of the small pipe, and thereby any moisture that it may contain is converted into dry steam. The radial tubes being at right angles to the current of heat, are placed in the drum in such a manner as to cause these currents to take a tortuous lateral course in their exit from the combustion chamber.

As a whole the exhibition reveals a remarkable progress made during the last fifty years in power machinery.

Turbine Nozzle Loss Analyzed by Air-Flow Measurement

THE wind tunnel, which has played an important part in research relating to airplane elements, is here utilized in principle, for investigating the suitability of turbine nozzles, valves, buckets, or other parts for transmitting steam efficiently

ABOUT four years ago air flow was tried out by the steam-turbine department of the General Electric Company for investigating flow conditions in which a 2-in. supply pipe was utilized. At the present time there are two test stands, each supplied through 6-in. pipes with air at 90 lb. per sq.in., which are run continuously, nights, days and overtime. More than 1,100 models have been tested, ranging in variety from turbine parts to elements of air compressors and the ventilation of electrical machinery. These are universally applicable to any problems concerning the flow of a fluid, whether compressible or incompressible. Those whose solution is in doubt, may frequently be solved quickly and economically by means of the air-flow test.

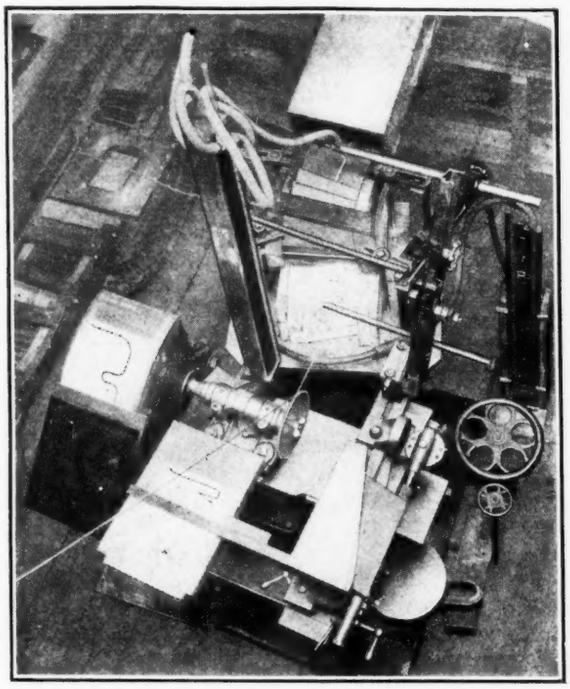


Fig. 1—Measuring impact at various points of air discharge from nozzle

The nozzle group in a horizontal position discharges air into the wooden chute in the background. In a turbine the nozzles would be held vertically by a diaphragm, discharging steam into rotating blades, and receiving steam from rotating vanes. The left side would line up with bucket tips, and the right with the disk edge.

An ingenious machine, making it possible to analyze flow conditions quickly and accurately, was constructed from a scrapped grinder. Efficiencies may be calculated from results obtained as described in a paper, "The Turbine Designer's Wind Tunnel," by H. Loring Wirt, for presentation at the annual meeting of the American Society of Mechanical Engineers, Dec. 1-4, 1924, New York City.

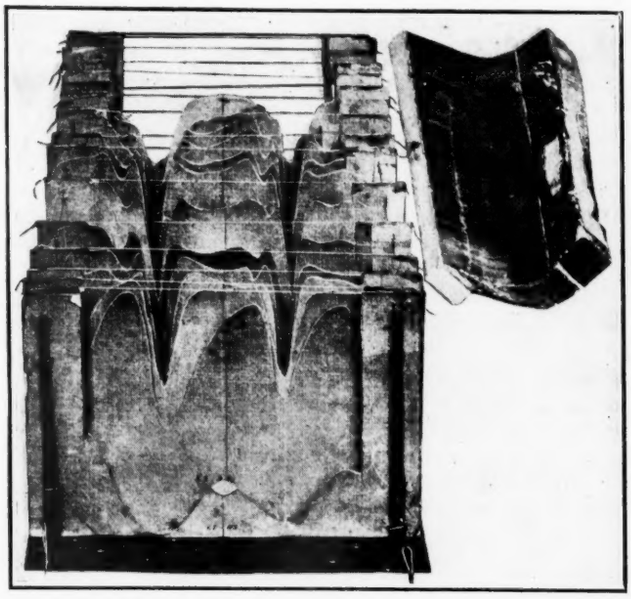


Fig. 2—How impact pressures vary in air discharged from inefficient nozzle

Templets of traverses lined up in relative positions are taken. Threads show impact values for perfect nozzle. Note valleys and depressions showing losses.

The model of some nozzles which are ordinarily situated in the diaphragm of a steam turbine, is shown as being tested in Fig. 1. Three adjacent nozzles of a group are built of mahogany, with steel partitions. Air discharged from the middle outlet is thus supported by

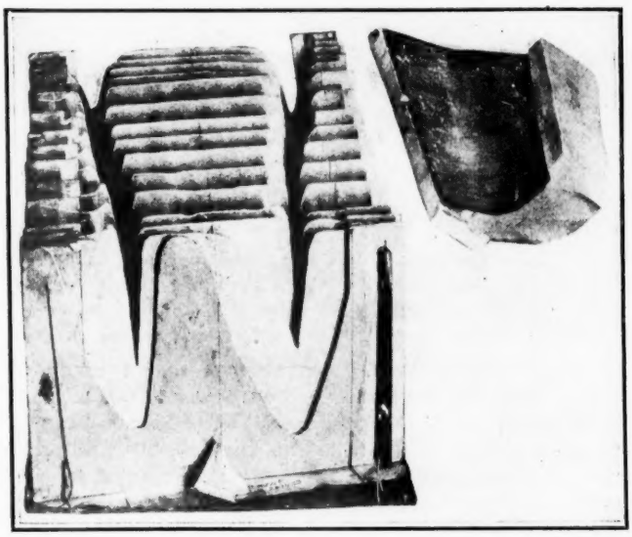


Fig. 3—Highly efficient nozzle traverses show uniformly high impact values

Except where nozzle partitions and edges cause slight reductions, high efficiencies are realized and threads are not required to indicate maximum impact.

that emitted from the nozzles on each side, in the same way that would occur in the actual machine, where many nozzles of this kind extend partly or entirely around the diaphragm.

The nozzles on test would therefore in practice be placed vertically, the right-hand side, shown in Fig. 1, being nearer the shaft and lining up with the edge of the disk, while the left-hand side would line up with the tips or shroud ring of the moving blades. Air discharge enters the chute shown in the background.

In an actual turbine this nozzle would receive steam from moving blades. The tips of the blades move somewhat faster than the roots, as the latter revolve with a shorter radius. Conditions of air entering the nozzle from these blades with respect to direction and speed of flow are somewhat different at the blade tips from those at the edge of the disk. In order to simulate the conditions of an actual turbine, the air duct that leads to the nozzle being tested is shaped and constructed so that air will be received under the same conditions of direction, etc., as that in an actual machine.

For measuring the angle of the air discharge, a special double vein angle meter has been developed which gives better results in the presence of high velocities than the single-vane type ordinarily employed.

The nozzle efficiency at any point may be calculated from impact measurement. An impact tube may be held on the discharge side, and from the impact pressure the pounds of air discharged per square inch, or from any other desired unit area, in a unit of time can be figured. From the pressure and velocity of the air that is supplied, the impact produced by a perfect nozzle expanding to atmospheric pressure can readily be calculated. If the actual impact pressure measured corresponded closely to the theoretical value, the calculation of the unit discharge is conveniently made from the usual laws of flow.

If this impact, however, is reduced appreciably below

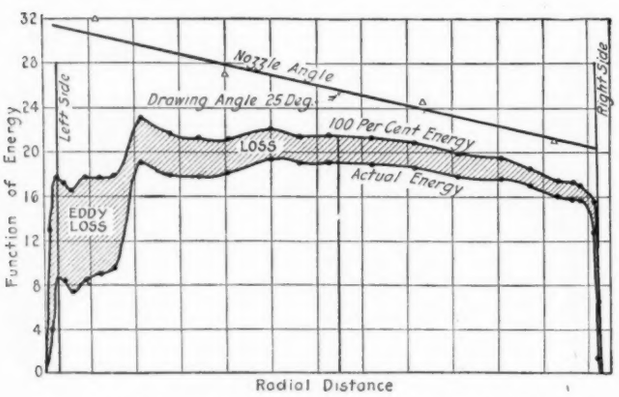


Fig. 4—Loss-efficiency diagram of inefficient nozzle

the theoretical amount, it is evident that friction or eddies, etc., have interfered to prevent efficient flow. Heat lost in friction is returned to the air, so that by assuming the air to be thus superheated, the discharge for a lower impact value than the maximum may also readily be figured. Special U-tubes are constructed by which the impact readings may be taken with the greatest facility.

It is possible to figure the amount of energy that would be liberated by expanding a pound of air from the initial to the final conditions in a perfect nozzle. From this we may calculate the amount of energy that any unit area of the nozzle outlet should supply if the weight of air were expanded at 100 per cent efficiency.

The weight of air that is found by test to be discharged per unit of area, and per unit of time, is multiplied by the amount of energy that one pound of air theoretically should supply. The result would represent, then, the energy that should be derived from all the air that is discharged from the unit of area in question, in the unit of time.

By testing the actual air discharged over a large number of points, over the nozzle outlet, and figuring

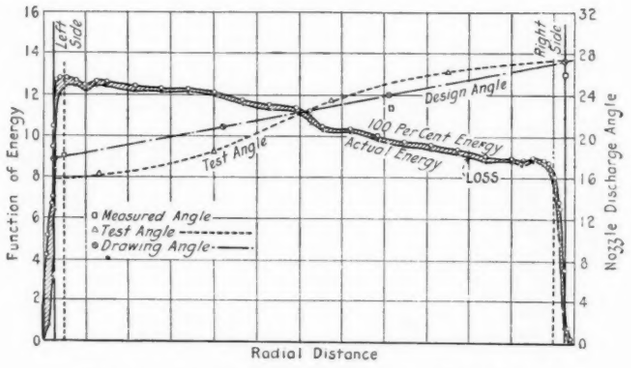


Fig. 5—Small eddy loss for well designed passage of expansion

the theoretical energy that should be discharged, the calculations, if suitably integrated, would represent the entire energy that a perfect nozzle would give for all the air passing through.

On the other hand, it is also possible to figure the amount of energy that actually is represented at each unit of area by the air that is given off. The energy in one pound of air as actually expanded may be calculated from the impact and other known conditions. Multiplying this energy unit by the amount of discharged air in the same way as before mentioned, would give an expression representing the energy actually realized from the chosen unit area of discharge in a unit of time.

Therefore, if the energy actually realized for each of the units of nozzle area is suitably integrated, we shall have an expression representing the entire amount of energy which the nozzle really supplies. The latter quantity divided by the theoretical energy will represent the nozzle efficiency. Also, for any unit area the efficiency of that particular area may be obtained by dividing energy actually supplied by that which it should supply. This also makes it possible to indicate how efficiency is distributed at various points in the nozzle discharge.

A tube, to receive the impact of the discharged air, can be moved across the face of the nozzles by a machine, as indicated in Fig. 1. At any point impact pressure may be read by a U-tube or other suitable device in full view of the operator. The impact tube in the figure is held close to the nozzle outlet by a horizontal arm. A rubber tube connects this to the U-tube in the foreground.

Ordinarily, the impact tube is moved across the face of the nozzle in approximately a circumferential direction, or in other words, it is fed practically parallel to the right-hand and left-hand edges. About thirty-five points are selected at which the impact pressure is

measured. Approximately thirty traverses are made for each nozzle, extending from the peripheral edge to the disk edge.

The tube travel also moves the drum shown at the left of the figure, whose motion is twenty times that of the impact tube. The impact value for each point is marked by hand on this recording drum. When the tube passes over a nozzle partition, a dip in this pressure naturally occurs due to the lessening of the flow by this partition.

The traverses that would be obtained for an inefficient type of nozzle are shown in Fig. 2. Templets are here set up, representing the curves actually plotted in traversing a number of points in a circumferential direction. The threads show the impact velocities that should occur in a perfect nozzle. Large dips or valleys in these traverses show loss due to nozzle partitions and eddies at the edges of the nozzles.

With an efficient type of nozzle, Fig. 3, the valleys or depressions are better filled out and, what is more important, the maximum impact values are realized quite uniformly, as indicated by the comparatively straight edges at the tops of the templets.

The distribution of efficiency in a nozzle that contains appreciable loss is shown in Fig. 4. Each traverse is integrated, from which the air flow corresponding to the unit area that it represents may be calculated. Both the perfect energy and the actual energy points are then figured. For each traverse, two points are therefore plotted, one representing 100 per cent energy for the same mass of air as discharged by a perfect nozzle, and the lower point, the actual energy given off by the air as discharged.

The values for each traverse are plotted so as to represent its actual position over the nozzle. Thus the traverse at the left of the nozzle is plotted at the left in Fig. 4, where its values appear. The traverse next toward the right has its values plotted at a distance representing its radial displacement from the first. The total efficiency by this test is 82.9 per cent.

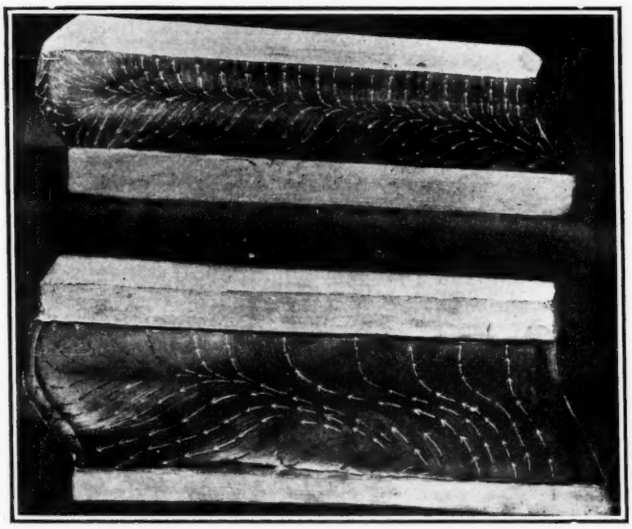


Fig. 6—Eddies and backward flow indicated by cast of inefficient nozzle

Spiral eddy at left accounts for low traverse in background of Fig. 2.

A nozzle curve with 96.6 per cent efficiency, which represents 13 per cent gain over the first one, is illustrated in Fig. 5, and its traverses are shown in Fig. 3.

There are two ways by which these results may be checked. The nozzle group may be tested with steam in a reaction machine and its efficiency thus determined, or the causes of loss, such as eddies and incorrect flow, may be indicated by a method of determining and recording actual flow directions on the interior surfaces of the nozzle.

Thus in Fig. 6 is indicated the actual flow for an inefficient nozzle, showing clearly the undesirable eddies that take place. The spiral eddy at the left is toward the blade tip and accounts for the low traverse in the background of Fig. 2. These are obtained by coating the interior surface with neatsfoot oil and graphite and then blowing the air through for a short time interval, which tends to produce lines in this coating, giving the direction of flow on the interior surfaces. Plaster of paris is then poured into the nozzle which, after it hardens, gives a permanent record of surface flow. The cast for an efficient nozzle, Fig. 7, indicates the more uniform flow and explains largely the better results obtained, as in Figs. 3 and 5.

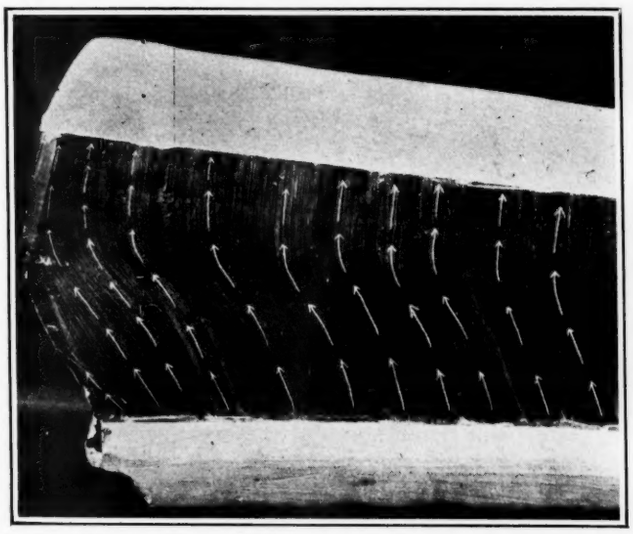


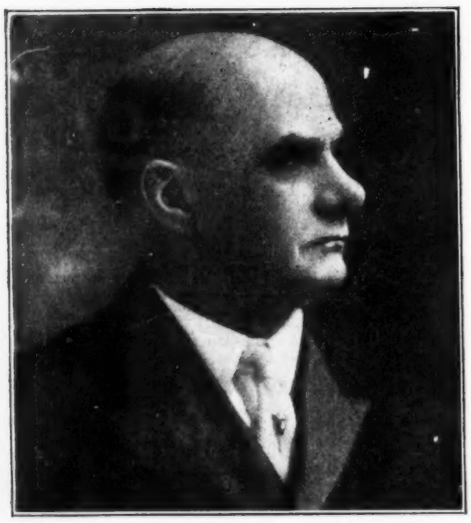
Fig. 7—Well distributed flow characteristics of efficient nozzle passage

The improved flow checks with traverses Fig. 3 and loss diagram Fig. 5.

By means of recording flow lines it has been found that steam in making a right-angle bend gives greatest loss with rounded corners. Square corners are slightly better, but when blades are introduced to assist in turning the steam around the bend, losses will then be lessened to one-sixth of the value with rounded corners.

With a new feature of design it is no longer necessary to follow a "hunch," but instead a model can be constructed and tested within a week, and in almost all cases a definite answer can be given as to how much gain or loss will be caused by the change.

In conclusion, although all of the foregoing may sound very simple and straightforward, it would be well to point out that a few isolated experiments are misleading and dangerous. For instance, nozzle and bucket actions are so interrelated that tests of either element alone may lead to wrong conclusions. Therefore, a background of all the previous work, including tests of eleven hundred models, must be freely drawn upon in order to design models for test, as well as to interpret test results correctly.



Operating Men of Forty Years Ago and of Today

By W. L. ABBOTT
Chief Operating Engineer
Commonwealth Edison Company, Chicago

IN WRITING for *Power*, one cannot be too careful with one's statements of fact; therefore, I trust that I may not be considered harsh in discussing, as I do, a past generation of operating men and that it will not be said that I speak of the departed as I would not if they were still here. I myself am of that pioneer race and can see them in their true light and respect them for their courage and resourcefulness in conquering, with their bare hands, the many new problems that arose while the art of central-station lighting was being developed.

It is thirty-nine years since I carelessly stumbled into the electric-lighting business in Chicago. If I had known anything about that business, I would have been more watchful of my step; but it was so easy and so convincing to figure that if the station had two hundred arc lamps, bringing in one hundred dollars each night, the business would pay for itself the first year and would make the owners rich the second year; and so I got in and never have succeeded in getting out. I have watched the changes come and go.

Equipment of Early Stations

The earliest central stations were series arc plants which were built by the men who operated them. I almost said "designed and built," but that would be incorrect. There were no designs. A tubular boiler and a high-speed engine belted to a dynamo or two located in some basement or back alley shed, together with two or three circuits running about the vicinity, stringing through customers' premises and lamps and, to save wire, returning by any shorter route to the station—this constituted a "central-station electric-light plant."

In locations where it was permissible the wires were run as a pole line through streets and alleys—sometimes on a crossarm, sometimes on one or more side brackets spiked to the pole. In metropolitan business districts the lines were carried across streets in pipes driven through the ground from one side to the other, and then under sidewalks, through basements, along building walls or over roofs. The perfect nonchalance with which linemen would deface pressed brick building fronts by drilling and plugging to attach blocks and brackets to carry the wires was matched only by their sublime trust that Providence would protect the public from their high-tension wires, strung through low-ceilinged basements, and their lamps hung within easy reach. In the days of wire with "Undertaker's" insulation, the electrocuted were the victims of their own carelessness. Claim agents, therefore, were unnecessary.

In these days we are occasionally taken aback by some enthusiastic applicant for employment, who, without any particular groundwork of education or experience, calmly asks for a position where he "can learn the business from the ground up." If such a person could get into the organization and really qualify, he would stand a good chance of becoming president, but in the old days we all came in with that ambition and with no other qualification.

Operating Man Had Diversified Duties

Formerly, a good handy man would trim lamps and help string wire during the afternoon and fire the boiler at night, except for the time he might be called out shooting trouble, the combination engine and dynamo tender doing his own firing the while.

The efficient solicitor who secured business was not above helping to string the wires that were to hook up his new customer. Most naturally, too, he made out the bills and did the collecting and—the drinking, as not the least important of his duties was to spend the change across the bar when he collected from the saloonkeeper. With a long string of saloons to visit (and we usually had them all), it is difficult in these later days to comprehend what collection day meant to the collector.

Another duty, which devolved generally upon the whole crew, but more particularly upon linemen and solicitors, was to fight the rival companies, of which usually one or more were threatening the border. At times a gentlemen's agreement would divide the territory, but when word would come to the office that the rival had "crossed the street," there would be a call to arms, a counter invasion, a cutting of rates and a cutting of wires, until a truce or consolidation was effected.

Such were the beginnings, but in a few years, by growth and consolidation, the number of lamps on the circuits became so great that power plants were built having condensing engines belted to shafting, from which the dynamos were driven. In the evening, when the full load was on, it was an impressive sight to

see the whirling shafting and belts and the rows of dynamos with their snarling commutators, like caged wildcats looking for someone to come within striking distance; and below were the throbbing engines, like blind giants bound to their task and shaking the building with their exertions. Some can enthuse at the sight of a storage battery whose ammeters indicate a heavy discharge; to others a turbine room, where nothing but the governors appear to be in motion, is thrilling; but in the arc-light station there was life and action and danger on every side.

Changed Conditions Brought About Classification of Duties

The electric lighting business was now on an established and orderly basis, with its various functions subdivided and systematized. There were the firemen with their shovels, the engine-room men with their oil cans, and the electricians in the dynamo room nursing their brushes and hot bearings. Outside were the lamp trimmers—young men with step-ladders and sprightly steps, walking briskly up and down the streets, in and out of stores and basements, putting the lamps in order for the night's run—and linemen, in whose heads alone were charted the exact routes of the various circuits through conduits, basements and stores, and over roofs.

This was the situation in the later '80's. In a little over ten years the series arc system of lighting had grown from nothing to be an established and commercially successful business, and those who were in it expected to see it continue to grow as it had grown. But a rival, or rather two rival rivals, had been born and were now entering the field to contend with the established series arc system and with each other for the mastery of the business. These rivals were the alternating-current system and the low-tension three-wire direct-current system. Before their attacks the series arc lamps soon began to lose ground. That system born in '76 reached the zenith of its influence about '95 and from that time declined, so that during the following ten years practically all of this equipment was gathered to its junk dealers.

Because of the limitations of the insulation used and the methods of circuit construction followed, few series arc machines were built of more than 100 lamps capacity. This meant that 50 kw. was the maximum machine size and circuit capacity, and this condition imposed a method of station construction involving a bewildering array of small units and complicated driving equipment.

Effect of Alternating Current Systems

The coming of the alternating-current system and the low-tension direct-current system brought with it larger generators, direct-connected to their engines. This completely changed the appearance of the power stations. Gone were the rows of fifty-light dynamos, belts, rope drives, jackshafts, and countershafts, clutch pulleys and pedestals; gone the switchboard with its maze of wires for circuit terminals on the back and its puzzle of transfer and coupling cords on its front; and as the stations were swept clear of this trash, many electricians (?) found their occupation also gone. Serene in the belief that ability to fill oil cups, trim commutator brushes and plug the switchboard established their standing, if not as mystics or members of a professional class, at least as highly skilled workmen, they had not noticed the changing world and were now more at sea with the new equipment than the mechanic's helper who assisted in its installation.

In one instance an old arc-light dynamo tender, who had been transferred to a position as operator on a direct-current switchboard, observing that the greater the number of coils in the field rheostat he cut out, the higher his voltage went, asked to have a few more coils added, as he needed more leeway in his pressure.

With its larger direct-connected units the new system at once simplified the engine room and vastly increased the output per employee, and as labor costs went down and the price of coal went up, the fuel cost became more important. Then the duty of the power-house designer and power-house superintendent became largely one of increasing the fuel economy. Better and larger boilers, higher pressures, automatic stokers, and all the other accessories that are so commonplace now, were scarcely dreamed of in the early '90's, the operation and maintenance of which justifies the highest type of intelligence, special education and training.

Specialists Now Required in the Operating Departments

Of course, with the coming of the steam turbine twenty years ago, the old world passed away and higher skill and higher specialization became imperative and is now sought out and paid for. A good boiler-room engineer now is paid as much as a general superintendent was then, and a fireman more than an old-time chief engineer.

The old-time operating man, often as a single individual, supervised or was in touch with all the details of all the various functions of the business. Now those functions, each vastly increased in importance and detail and as numerous as the various classes of equipment within and without the power house, have each its specialist or corps of specialists in charge, each knowing thoroughly his particular duties, but knowing little else.

In a large organization the man aloft, setting the trips on the coal conveyor, has little to do with those who unload the coal or with the fireman at the lower end of the coal spout. The turbine operator gets his energy from a steam pipe coming through the wall on one side of the turbine room, and that energy, as transformed, goes out on an electric cable through the wall on the other side. What or who is at the other end of the pipe or of the cable concerns him little. The switchboard operator, isolated and inclosed by four paneled walls, is conscious that he sits on the pinnacle of importance. What he does not know about things outside of his cell would make a handbook of useful information on power-house design and operation. And there is the load dispatcher or system operator, who pretends to carry inside of a No. 8 hatband all the really useful information that is needed by anyone. He considers it significant that the president and the lesser luminaries go home at night, leaving him to run the company sixteen hours a day. He only wonders why they spend so much time around the office when he is on the job.

I might go on up with this review, but prudence dictates that I do not carry it too high. I will therefore close it, with the frank admission that I have the profoundest respect for the wisdom, knowledge, skill and general efficiency of those present-day operating men who started to learn the central-station business thirty to forty years ago.

Specific Speed, Its Meaning and Use as Applied to Hydraulic Turbines

Specific Speed as a Guide to Classification of Hydraulic Turbines—Effects of a Change of Load and Head on Specific Speed—Why High Specific Speed Turbines Are Used on Low Heads and Low Specific Speed Runners Are Used on High Heads

By R. T. LIVINGSTON
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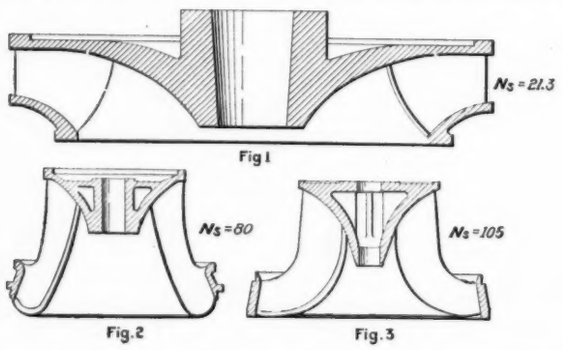
THE term specific speed is used in engineering as the guide to the type of a hydraulic turbine. Thus we may have a turbine spoken of as having a specific speed of 30, 80 or 105, as the case may be. To those acquainted with the meaning of the term, a picture of the turbine is formed in their minds as soon as the value of specific speed is given, but to the man not so thoroughly familiar with hydraulic-turbine practice this value means little or nothing, and to him a little explanation would not be amiss. A cross-section of a Francis type turbine of specific speed 20 would appear about as shown in Fig. 1, of 80 as in Fig. 2, and of 105 as in Fig. 3. With these changes in specific speed, in turbines of the same diameter, for example, come changes in the height of gate space, in the inlet and outlet angles and, in fact, the whole construction of the runner changes. The guide vanes, the casing, the draft tube and even to some extent the material of which the runner is made change.



Figs. 1 to 3—Cross-sections of Francis-type turbines having different specific speeds

Term Specific Speed Widely Used

The use of the term specific speed not only gives an immediate idea of the general features of a runner, but to some extent the installation and its value are vouched for by its widespread and general use throughout the turbine field. Its advantages are such that this method of rating machines has spread to other fields; in centrifugal pump practice, for example, it is daily becoming more common, while in the fields of centrifugal fans it is not unknown, though in a greatly modified form.

Specific speed, "unit speed," or "type characteristic," as the term is sometimes called, is defined as "that speed at which a runner would operate if reduced geometrically to such a size that it would produce one horsepower when operating under one foot working head," and its value is given by the formula,

$$N_s = \frac{N \times \sqrt{HP}}{H^{\frac{5}{4}}}$$

in which N_s is the specific speed, N the revolutions per minute, HP the rated horsepower of the machine, and H the rated head in feet.

Note: When the head is expressed in meters and the power in metric horsepower, as is frequently done, the specific speed is 4.45 times as great as when the English units are used as in the formula.

Runner Reduced Geometrically

When it is said "reduced geometrically" it is meant that the whole runner is reduced in size by the same proportion, exactly as if it were photographed down. Thus, if the diameter is reduced to one-half its original length, all other lineal dimensions must be reduced to one-half and all areas to one-fourth the original size. In consequence the weight would be reduced to one-eighth. The angles, however, would remain unchanged.

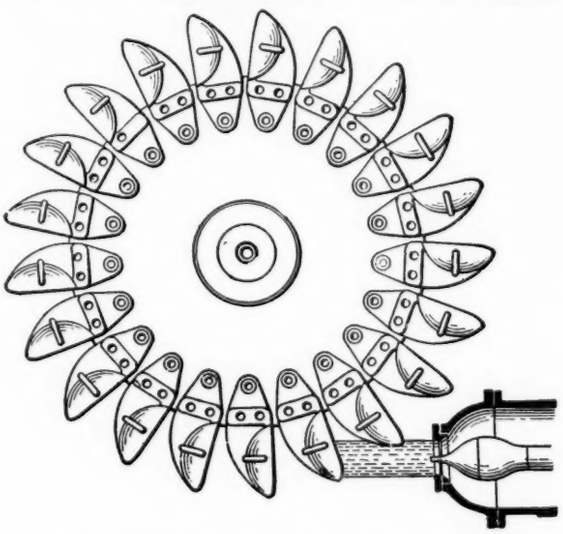


Fig. 4—Impulse, or Pelton type, waterwheel

While not generally understood, it must be realized that in order to use specific speed as a true guide to the type of the turbine it must be taken at rated head, horsepower and speed, which in turn should be taken at maximum efficiency. However, it is the accepted practice by manufacturers to base the specific speed of their turbine on the normal rating of the machine.

From the formula it is apparent that a change in any one of the factors—speed, horsepower or head—will change the value of the specific speed. Hence, in order to have a basis for comparison between various turbines, it is necessary that specific speed be measured at some definite point, the same point on all turbines. It would seem that the point of maximum efficiency was the most logical and, in fact, the point where a comparison between turbines on this basis would be correct.

The question may well be asked, why a varying quantity was adopted as a standard and why, when a turbine is designed for a certain specific speed, it does not always remain at that specific speed? Other factors have been considered as a basis of comparison, such as the ratio between the peripheral speed of the inlet edge of the runner and the theoretical spouting velocity of water (spoken of as Φ) and the ratio between the height of the gate space and the diameter of the turbine $\left(\text{called } \frac{B}{D}\right)$, but neither of these two quantities takes into account all three of the most essential items, the head, the horsepower and the speed. Hence, they are not so good a guide to the turbine as specific speed.

Hydraulic-turbine engineers have adopted "specific speed" as a "rating" of the turbine, and while the rating remains the same, that which the turbine was designed for, yet the actual developed specific speed will vary from zero at zero r.p.m. and zero efficiency to the rated specific speed at rated speed and horsepower and then on to a maximum value at runaway speed where the efficiency again returns to zero.

A turbine may produce the same specific speed at a number of different positions of the gate for the same head, but in such cases both the horsepower and the speed will vary. When the product of the square root of the horsepower and the revolutions remain constant, the specific speed remains constant, that is, of course, when the head is kept constant. On the other hand, if all three factors are allowed to vary, the wheel will produce the same specific speed at an infinite number of different heads, but it must be remembered that the revolutions per minute and the horsepower must vary in such a manner that the product of the two to the proper powers will always remain the same.

While it is true that any turbine, no matter what its rated specific speed may be, will develop a wide range of specific speeds, a properly designed unit develops its best efficiency at or near its rated specific speed, and any change from this is obtained at a sacrifice in efficiency and in extreme cases a loss in power. For example, if a given wheel, rated at 10,000 hp., is designed to operate under a head of 60 ft. at a specific speed of 60, its normal speed will be about 100 r.p.m. If the head is reduced to 55 ft. and the speed and horsepower are kept constant, the specific speed will increase to 66. This is the same as holding the head constant on the wheel and increasing the speed. Either one will result in a decrease in efficiency.

A similar condition is inherent in the operation of almost all turbines, since they generally operate at constant head and speed but the load varies. In the foregoing problem the normal load on the unit is 10,000 hp. If the load is reduced to 5,000 hp., then the specific speed at this load is about 42. If the turbine is overloaded, the specific speed is increased. All these changes from normal in the operation of a turbine that is properly designed are reflected in a decrease in efficiency. The loss in efficiency is important, but the tendency to cause corrosion of the runners when normal conditions are disturbed also cannot be overlooked.

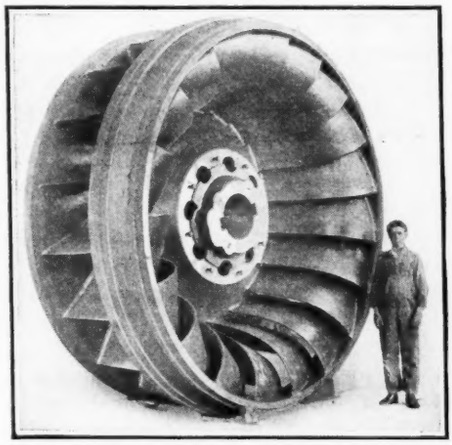


Fig. 5—Turbine runner rated at 55,000 hp. at 187.5 r.p.m. under a 305-ft. head; specific speed, 35

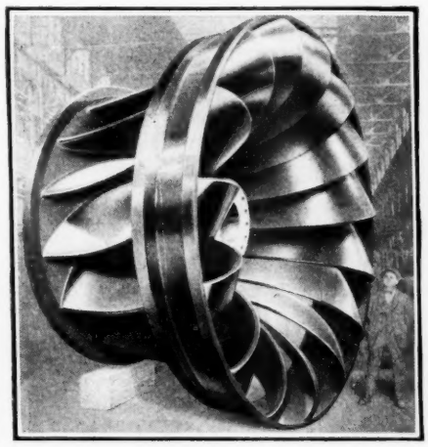


Fig. 6—Turbine runner rated at 24,000 hp. at 100 r.p.m. under a 70-ft. head; specific speed, 80

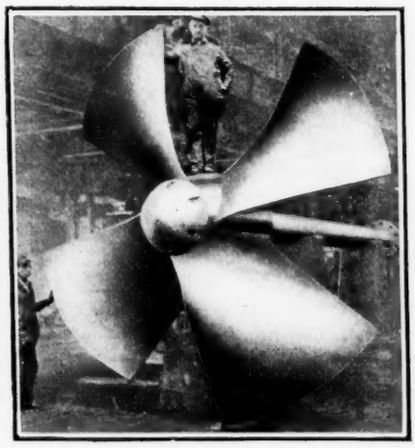


Fig. 7—Turbine runner rated at 2,200 hp. at 80 r.p.m. under a 13-ft. head; specific speed, 152

When a turbine is properly designed and is operating at its normal specific speed, the water flows through it in smooth streams. A change in specific speed, due to either a change in load, speed, or head, tends to disturb the flow through the runner and cause corrosion in places where the water leaves the surfaces of the buckets and creates a vacuum. In these voids oxygen is liberated, which attacks the metal. It should not be understood from this that operating a turbine at other than its normal condition is the only thing that causes corrosion. There are a number of other factors that have an important bearing on the problem, but are beyond the scope of this discussion.

The specific speed of hydraulic turbines varies with the type. Contrary to what might be expected, the Pelton type of wheel, Fig. 4, which is used on high heads, has the lowest speed. In so far as the spouting velocity of the water is concerned, this type should have the highest speed of any type of waterwheel. As can be seen from the figure, only a small part of the wheel's

periphery at any one time is affecting the production of power, whereas in the Francis type the whole wheel is used. As a result, when comparing the two wheels for a given horsepower output, the diameter of the Pelton wheel becomes so large that its speed must be reduced to maintain about the same water velocities in the two wheels, which range from 60 to 75 per cent of the spouting velocity, whereas the rim velocity of the Pelton or impulse wheel is 50 per cent of the spouting velocity compared to 60 to 90 per cent for the Francis or reaction type.

This inherently slow speed of the Pelton wheel gives it a specific-speed range of 5 and less. With the Francis type of wheel the specific speed range is from about 10 to about 110 in general practice, although there are records of runners of the Francis type being developed for a specific speed of 176.5. For specific speeds above 100 the so-called propeller class of turbine, Fig. 7, of which there are a number of different types, is coming into wide use. This type has been developed for specific speeds of 235 and higher, although 140 to 160 is a quite common range in which good working efficiencies are obtained.

Comparison of Low- and High-Head Wheels

In comparing Fig. 5 with Fig. 7, it will be seen that the high-head wheel has a low specific speed and the low-head wheel has a high specific speed. If the spouting velocity of the water is considered, it would naturally be expected that the high-head wheel would have a higher specific speed than the low-head wheel. Here specific speed should not be confused with the actual r.p.m. of the turbines. A high-head wheel always operates at a greater number of revolutions per minute than a low-head wheel of the same capacity. However, if both runners are reduced in size to where they would each develop one horsepower under one-foot head, it would be found that the model of the low-head runner would operate at a much higher speed than that of the high-head runner. The problem simply comes down to choosing the highest speed runner that will give satisfactory operation for the low-head plant and selecting for the high-head plant a runner that will operate at a reasonable speed and have other satisfactory operating characteristics.

According to the laws for a hydraulic turbine runner the horsepower varies as the three-halves power of the head, and the speed as the square root of the heads. As an illustration of how this works out, take the case of a 566-hp. wheel operating under a 30-ft. head at 150 r.p.m. If it were possible to use this wheel under a 600-ft. head, it would have a speed equal to $\sqrt{30} : \sqrt{600} :: 150 : x$, or 670 r.p.m., and the horsepower rating will be $30^{\frac{3}{2}} : 600^{\frac{3}{2}} :: 566 : x$, or 50,000. For the low head the wheel represents a fair standard practice for small Francis wheels and has a specific speed of about 50. However, when this wheel is applied to high heads its speed is excessive and its horsepower goes beyond any reasonable value for the design of runner and cannot be used. Therefore a design having a lower speed will have to be used or, in other words, a runner having a lower specific speed must be used for the high-head turbine.

This problem brings out clearly the significance of specific speed in turbine design. Considering the horsepower and speed of the two wheels as given in the foregoing, the speed of the high-head machine would indicate that it was a much higher speed design than the low-head machine. However, when they are operated under the same head, they are one and the same machine and are of a medium-speed design. It is evident from this that before any conclusions can be formed about the speed of a hydraulic turbine in relation to the head under which it is to operate, the specific speed of the runner must be determined to get a fair comparison with other units.

The Heating System of the Power Plant

By Edwin C. Warfield

This article covers briefly a feature of the modern power plant that receives little attention—the heating system. The importance of giving this matter early consideration in the design of the plant may well be considered when it is realized that winter usually finds the building erected and under roof with the turbines, auxiliaries and piping not yet in place. At this period the heating system should be installed—not a makeshift arrangement but the finished product with the exception of the equipment adjacent to the main point of supply, which, it will be seen later, cannot be installed until the station is complete. Temporary connections may be made to a small boiler, a hoisting-engine boiler usually being most convenient.

Two-Pipe Up-Feed System Generally Best

It is usually best to install a two-pipe up-feed steam system. The entire supply riser system will then drip back into the supply main. All riser connections will be taken off the top of the main. Should it be necessary to place radiators below the supply main, the down-feed risers supplying them will be so short that it will not be necessary to drip them. Expansion in the piping must be cared for by suitable swing connections and expansion bends. The return main will be run below the ground floor, if practical; otherwise, it will be run above the floor with trenches at the doors, and the radiators hung to the wall at a height that will permit plenty of room for connection to the return main at its highest point. All pockets in the return main will be bypassed with an air line and all pockets in the steam main suitably dripped.

Direct cast-iron radiation with the supply at the upper corner and the eccentric bushed return at the lower opposite corner of the radiator will be used. Supply valves are preferably of the packless type and return valves of the thermostatic type. The steam pressure should be between five and ten pounds, and on this basis a pressure drop of one pound to the farthest radiator may be safely allowed. The return piping should be sized and laid out for a gravity system if possible and no lift fittings used. As a return pump, an electrically driven centrifugal with automatic float control is best. Several of these pumps are now on the market with the added feature of being capable of maintaining a vacuum in the return line.

Probably the most economical point of attachment for the steam supply is to bleed the main turbine at about 60 lb. gage pressure (full load) and use a reducing valve to obtain 8 lb. pressure on the supply line. This point of bleeding should be sufficiently high so that at minimum turbine load there is no danger of the pressure falling below 8 lb. at the point of bleeding. Exhaust steam from the station auxiliaries may be utilized

ff there is an excess of it available above feed-water heating requirements. An auxiliary connection should also be taken from the boiler drums, so that the system may be kept in operation even though the main turbine is not running.

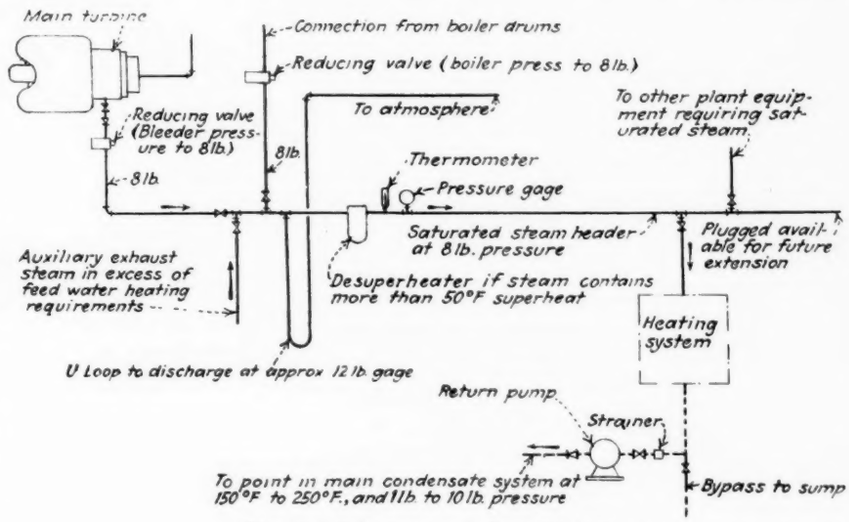
It may be mentioned here that a saturated steam header is usually advisable in any station and the connections as described will serve both the heating system and the steam header. A reducing valve will necessarily be installed in the boiler-drum connection, and if the turbine or drum steam contains more than 30-deg. of superheat after reduction, a desuperheater should also be installed. At some point in the main supply line to the heating system there should be a safety valve in the form of a U-loop. This form of valve never sticks and is positive in its action.

The question of bleeding the main units should always be taken up with the turbine manufacturers, as there are, of course, cases in which such practice would not be economical. The factors affecting this matter are the quantity of low-pressure steam required, the size and design of main turbines and the quantity of low-pressure steam available from the exhaust of the auxiliaries, or other sources.

The condensate from the heating system is pure water, and after the first two weeks of operation, when the rust, scale and sand in the radiators and piping are being carried off, it will be suitable for boiler feed. A strainer should be provided in the return line before reaching the vacuum pump, and there should be a bypass to the sump or other convenient place of disposal. The returns may enter the main condensate system at some point near their own temperature and at a pressure not exceeding 10 lb. gage. If an open feed-water heater is employed, it will usually be found the best place. In some cases the receiver drip from a high-heat-level condenser may be found best. While it is possible to enter the main condensate system at a point below atmospheric pressure, such as a bleeder heater or the main condenser hotwell, such practice is not to be recommended, since any leakage in the heating system might affect the vacuum of the main units.

It may be mentioned here that hot air can be employed to heat the plant by using an air heater in the breeching somewhat similar to the usual economizer and by deflecting into the building a portion of the air used for cooling the generators. However, this method is not generally employed owing to the fact that as far as the breeching is concerned any restriction in the path of the waste gases places an added load on the draft fan or on the stack, and another objection is that the station is usually so filled with piping that there is little room for the necessary duct work to distribute the hot air. Furthermore, the heat distributed by such a system is directly proportional to the station load, which is the reverse of the ideal condition. Such a system is, moreover, not available during the construction period.

Another scheme of heating, which has proved very successful for industrial plants but has been little used in power plants, is the unit heater, which is essentially a holder containing pipe coils through which steam circulates. By means of a motor-driven fan outside air is forced around the pipe coils and into the building. The steam in the coils is condensed and imparts its latent heat to the air. The unit scheme, as described, will mean larger steam piping but less of it than is necessary for cast-iron radiators, since the number of air heaters will be small compared with the number of radiators necessary to heat the same building. Very little duct work is necessary with the unit scheme, and it has the possibility of being available as a mechanical ventilating system in the summer time. Its disadvantages are that the heaters take up floor space or, if suspended, require a steel framework support, and secondly, in most cases both the initial and operating costs will be greater than the cost of a direct-radiation system.


Main turbine
Connection from boiler drums
Reducing valve (boiler press to 8lb.)
To atmosphere
To other plant equipment requiring saturated steam
Reducing valve (Bleeder pressure to 8lb.)
8lb
8lb
Thermometer
Pressure gage
Saturated steam header at 8lb. pressure
Plugged available for future extension
Auxiliary exhaust steam in excess of feed water heating requirements
Desuperheater if steam contains more than 50°F superheat
Heating system
U Loop to discharge at approx 12lb gage
Return pump
Strainer
To point in main condensate system at 150°F to 250°F., and 1lb to 10lb pressure
Bypass to sump

Typical Diagram of Connections

In plants where mechanical ventilation in summer is an important item, the unit heaters deserve consideration. A combination of direct radiation and unit heaters may be often used to advantage.

According to W. H. Patchell, president of the Institution of Mechanical Engineers, the present electricity supply of England is handled in 335 localities by the local authorities and in 225 by the private companies, giving a total of 560 systems. During the war a coal-conservation investigating commission found that the railways and electric authorities were large users of fuel. The stations used up to six pounds per kilowatt-hour, and the commission recommended that many of these be scrapped and also that the number of electrical supply areas be reduced from 560 to 16 for the United Kingdom. At the same time the commission recommended that 20,000,000 pounds sterling should be raised by the government for better plants. This plank had the strong support of the labor party because it promised work.

If, as seems to be definitely established, the total heat of steam decreases after a certain pressure (around 500 lb.) is passed, throttling of dry saturated steam from very high pressures will result in wet steam, provided the throttling process is stopped before the pressure falls too low.

Air Preheaters and Their Application

ALTHOUGH air preheaters were thoroughly tested and operated in an installation some forty-two years ago and in special applications such as for the elimination of smoke, etc., preheated air has been more or less used, it is only recently that the recovery of heat from the stack gases in stationary practice by this method has become widely recognized as commercially justifiable. A comparatively few plants are now utilizing air preheaters, while many more have either ordered units of this character or are considering their installation, both in connection with and without economizers. Preheating, however, has been extensively used abroad, although under conditions hardly comparable with American practice.

Besides the apparent advantage of utilizing heat otherwise wasted, a number of conditions are involved when air is thus preheated, some of which are particularly significant in view of recent furnace developments.

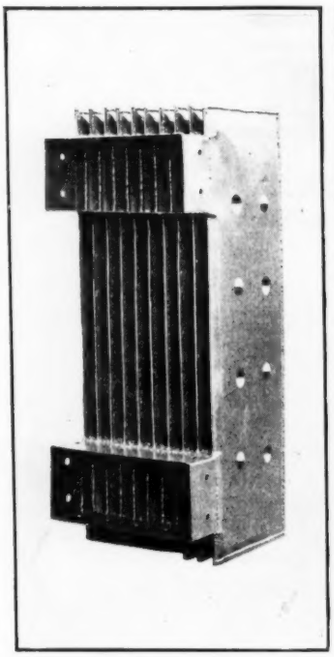


Fig. 1—Element with sheet spacers for Fig. 2

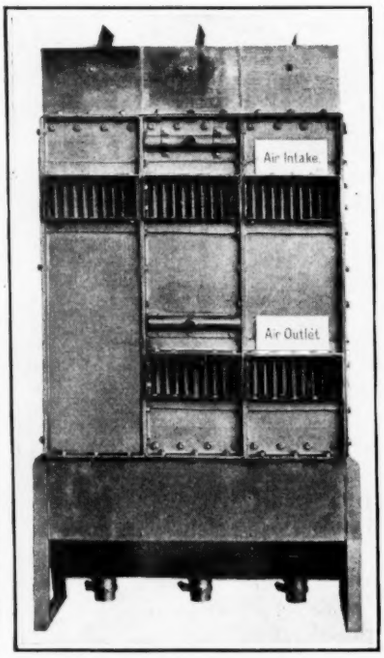


Fig. 2—Connery unit with soot hopper

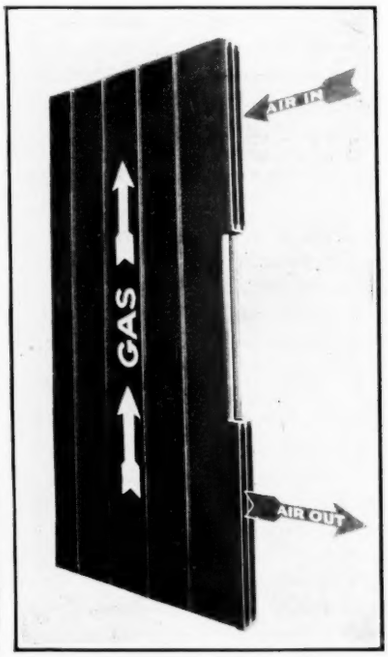


Fig. 3—Welded element with baffles

As mentioned in the April 18, 1922, issue, J. C. Hoadley, at the Pacific Mills, Lawrence, Mass., made extensive tests on boilers equipped with air heaters in 1881 and 1882. The tests were conducted and written up in most thorough manner, which resulted in the conclusion that 10 to 15 per cent increase in boiler efficiency could easily be thus obtained. The elaborate account of tests on Hoadley's preheaters and those of modern construction will give an indication of what may be expected from installing a preheater. Thus Hoadley increased the over-all efficiency from 68.87 to 81.43 per cent, which was a rise of 81.43 — 68.87 = 12.56 per cent, or a net gain of $\frac{12.56}{68.87} = 18.2$ per cent.

The first preheater Hoadley built consisted of 240 horizontal 2-in. tubes, 20 ft. long. Each tube was contained inside of a 3-in. sheet iron tube, the flue gases traveling through the smaller, and the air through the space between the inner and the outer tubes. An improved preheater consisted of 2-in. tubes for passing the furnace gases and contained vertical baffles to force the air in diagonal directions through the tube bank. This latter arrangement was found to cost less and yield better results than the former.

Preheaters represent from one-half to twice the boiler-heating surface. They are at present limited in temperature of the heated air to about 450 deg. F. With pulverized fuel this may be exceeded, the actual temperature depending on the amount that is commercially justified.

Along with the gains due to the recovery of heat from the stack gases, there is a secondary gain ordinarily realized due to better combustion. Unconsumed carbon in the ash is much reduced by the utilization of warmer entering furnace air and the percentage of CO_2 is increased. Efficiency of heat transfer is somewhat improved owing to higher furnace temperature and greater absorption of radiant heat.

On account of the fact that radiant heat which is given off by combustion, varies about as the fourth power of the absolute furnace temperature, gas leaving the grate is heated to a much less extent than the range through which the air is preheated. Thus, where a comparatively large amount of water-cooled surface is exposed, which would especially apply to boiler settings containing heat-absorbing surfaces in place of refractories, radiant heat would be absorbed to such an extent that but little appreciable rise of furnace temperature might result. Refractories, on the other hand, give off or reflect the heat received also in about the same ratio as furnace gases, thus tending to maintain high gas temperature. If the furnace air is increased from 70

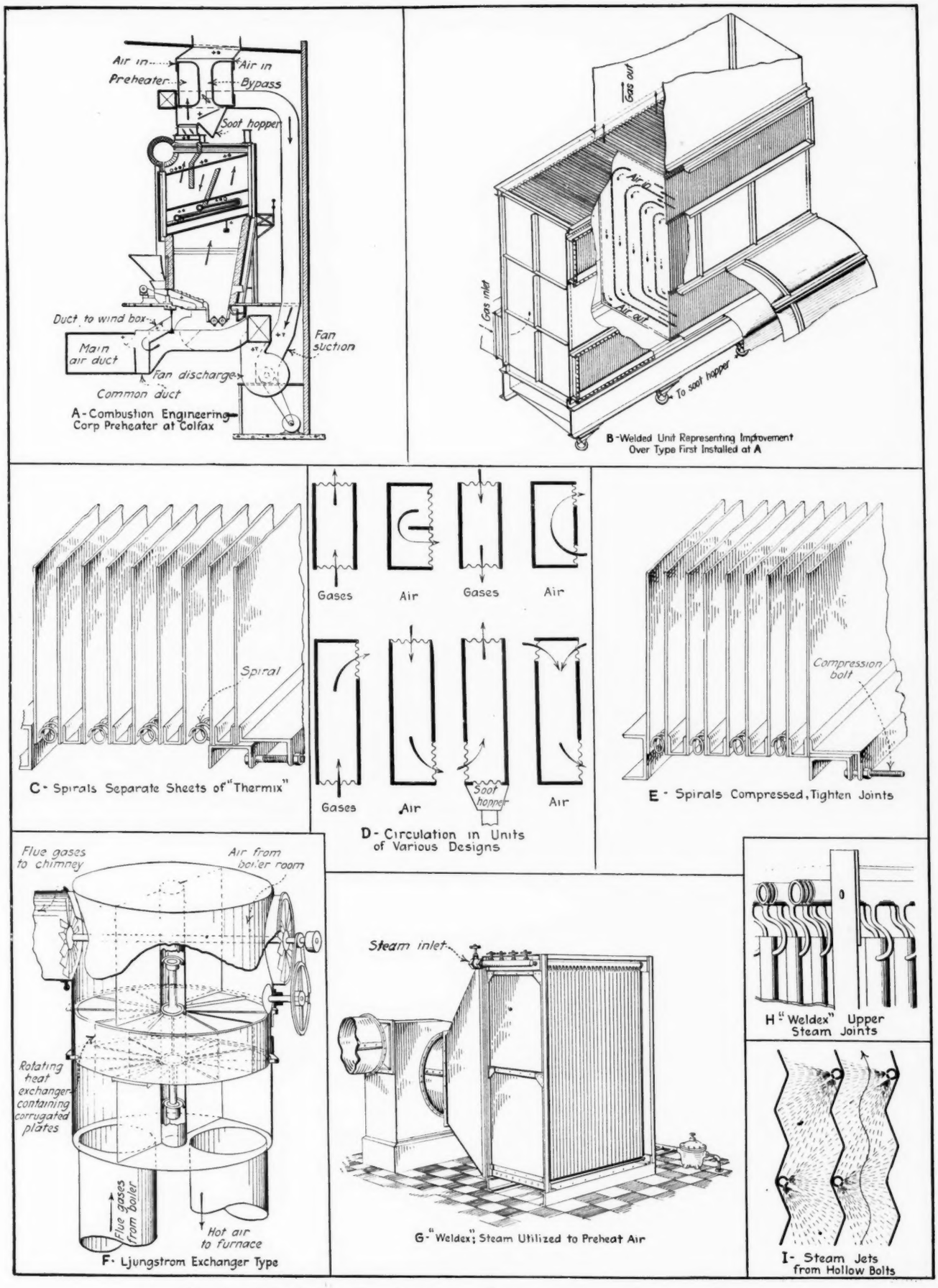


Fig. 4—Some types of preheaters and their principles of construction

to 170 deg. F., the furnace temperature might be expected ordinarily to rise 10 to 20 deg. An investigation in France indicated that the furnace temperature varies from one-tenth to one-third of that of the preheated air, for the average plant.

Experiments by M. Roszak, chief engineer of the Babcock & Wilcox Company of France, in an article on the subject of preheated air, published by the Society of Civil Engineers of France, 1923, stated that from his experiments grates could be made to utilize incoming air successfully at temperatures of 200 to 250 deg. C., corresponding to 392 and 482 deg. F. He considers preheaters with the necessary grate construction could be utilized at 300 to 400 deg. C., corresponding to 572 and 752 deg. F. for entering furnace air without difficulty.

In the case of pulverized fuel where grates or stokers do not interfere, high air temperatures are possible. As water-cooled furnace walls are sometimes utilized in such installations, the preheater is well adapted for use with pulverized coal for fuel.

Experiments show that air preheating not only tends to raise the efficiency curve of the boiler but also tends to make the curve flatter. The combustion space may be decreased, especially in the presence of coal high in volatile matter which may be better consumed by introducing preheated air above the fire.

Largely on account of the utilization of radiant heat and better heat transfer in the region of the furnace, air leaving the boiler is ordinarily somewhat lower in

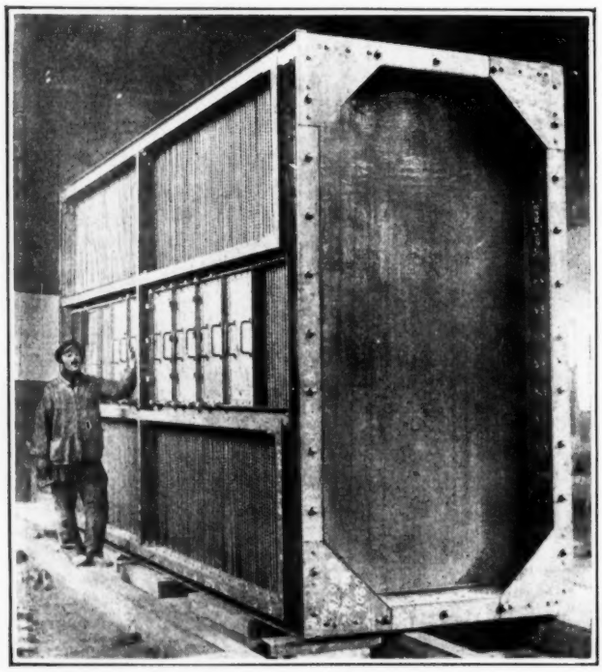


Fig. 5—Doors for cleaning gas spaces placed between air intake and outlet of "Thermix"

temperature when a preheater is used than without one at an equal rating. Engineers are not in agreement as to this condition being theoretically justified, but many tests show this in practice. Thus for an equal temperature of exit boiler gas, a higher CO_2 percentage may be carried; also a higher rating for an equal exit temperature. (This refers to gas entering preheater flues.)

Coals with high moisture content may be more efficiently burned, and heat ordinarily escaping may be reclaimed and utilized to better advantage. Evaporation has been increased 40 per cent with wood pulp for fuel, by the application of preheating.

Where higher steam temperatures are encountered, a higher temperature of gas leaving the boiler ordinarily results, so that preheaters become more advantageous.

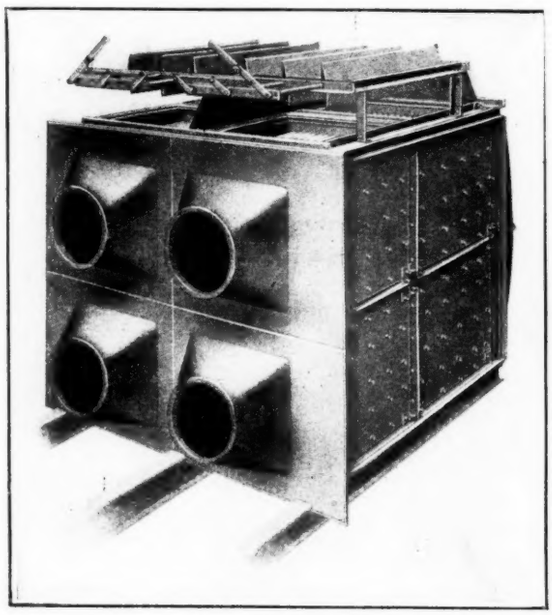


Fig. 6—Dampers arranged above "Rotator" unit

The aforementioned conditions lead to some interesting sidelights on the preheating of air. An attempt to sum these up as in the following paragraphs, may constitute a more complete presentation of the subject. Statements refer primarily to installations without economizers.

1. Recovery of heat from the stack gases raises the boiler efficiency from 4 to 10 per cent ordinarily.
2. Improvement in combustion may represent a further rise in boiler efficiency.
3. Difficulty from clinkering may be encountered with a coal having a relatively low ash-fusing point, as a sufficiently low fusing ash would make preheating detrimental.
4. Temperature of the preheated air is restricted by stokers or grates to 400 or 450 deg. F. due probably to limited knowledge rather than physical reasons, but reaches 400 to 550 deg. F. abroad. Special stoker designs have been developed to work with preheated air.
5. Furnace temperature as found abroad is increased ordinarily one-tenth to one-third of the range through which air is preheated.
6. Temperature of gases leaving the boiler is usually lower with preheated air at a given rating than without preheating.
7. Preheating is particularly adapted to furnaces where water- or air-cooled surfaces readily absorb radiant heat.
8. Owing to air infiltration into gases before reaching the preheater, and to some stack loss being practically unavoidable, only 75 to 80 per cent of the stack gas heat is ordinarily possible of recovery.

9. Owing to infiltration, less air is usually preheated than that passed up the stack.

10. The limit on preheating temperature which stokers or grates impose is not present with pulverized fuel. Other restricting conditions, such as refractories or ash fusibility may be present.

11. The tendency is to raise the efficiency curve of the boiler, making operation at higher ratings more advantageous.

12. In many cases the boiler-efficiency curve thus becomes flatter.

13. High volatile coals may be burned to better advantage in small furnaces by admitting warm air at points above the fuel bed.

14. Increases capacity of installation 10 to 15 per cent, provided temperatures are not detrimental in furnace.

15. Makes it possible to carry higher CO_2 percentage at an equal temperature of gas leaving the boiler.

16. High moisture content of coal involves less relative loss with preheated air, especially in the presence of ample water- or air-cooled surface, which restricts the rise in combustion temperature.

17. For higher steam temperatures, involving warmer stack gas, air preheaters are increasingly desirable.

18. Favors utilization of cheaper fuels, such as with high moisture, volatile or ash.

19. When highly corrosive stack gases are encountered, special provisions against this condition may be required in preheaters.

20. Preheating increases the necessary length of air or gas ducts.

21. Leaks in the furnace or warm air duct may cause unpleasant boiler-room conditions and tend to lessen the care with which the boiler is operated. Radiation from uncovered ducts may prove objectionable.

22. Where conditions require a fan on the suction

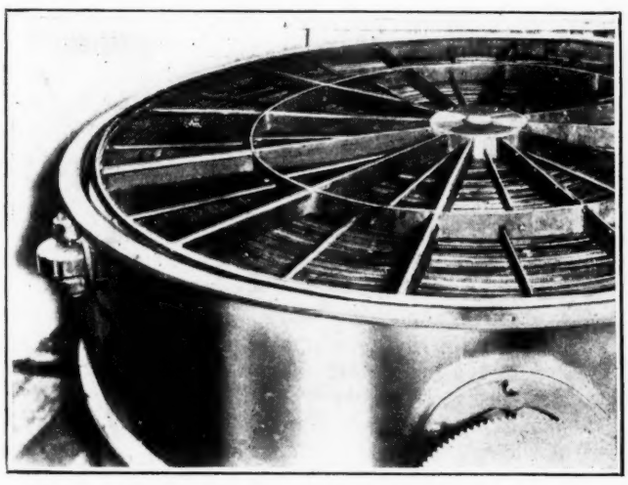


Fig. 7—Revolving heat exchanger element contains corrugated plates partitioned into sectors

air side, the greater volume of air involves larger fan and more power for operation.

The unit in Fig. 2, an interior element of which is shown in Fig. 1, is a welded structure built by the Connery Company. The sheets forming partitions are prevented from collapsing against each other by means of depressions or knobs pressed into the metal, as in Fig. 1. Restriction of either the air or gas passages is thus prevented. The elements may be readily taken apart, and a variety of forms may be built up suitable to the requirements of any special installation.

Attention was quite generally attracted toward the preheating of furnace air when a plate type unit was installed at the Colfax Station, a general plan of which appears in Fig. 4 at *A*. A paper read before the A.S.M.E. by C. W. E. Clarke, Dec. 6, 1923, described

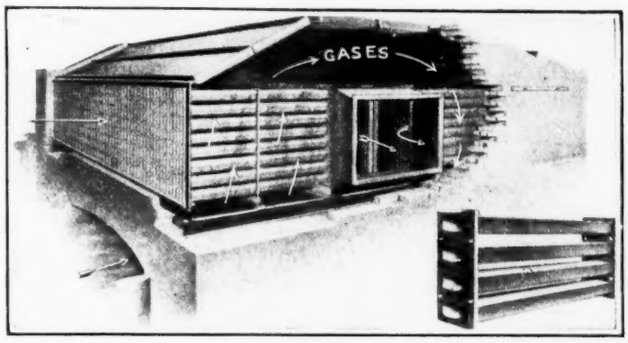


Fig. 8—Cast-iron rectangular tube unit at right utilized in "Green" preheater shown above

elaborate tests, in which it was shown that the desired windbox temperature of 235 deg. F. was equivalently realized, and the efficiency curve both raised and flattened appreciably as a result.

The original unit was of riveted and calked construction, allowing appreciable air infiltration. As a result of the experiment an improved welded type was developed by the Combustion Engineering Corp. This concern is associated with the Underfeed Stoker Co., Ltd., which has for some time produced preheaters abroad. Angle-iron baffles are applied, Fig. 3, to prevent gas or air stratification and secure a uniform rate of heat transfer. A modern design appears at *B*, Fig. 4.

The "Thermix" type is the outgrowth of many years in manufacturing preheaters abroad by the Prat-Daniel Corp. In Fig. 5 the furnace flue gases may pass vertically between thin partitions while the air enters from the upper opening and is discharged at the lower. Other constructions of course may be utilized, according to the plant requirements. Several forms of gas and air flow paths are shown at *D*, Fig. 4. Air distribution is thus arranged by means of special openings rather than by complicated baffling.

The distinguishing feature of this preheater is that both riveted and welded joints between plates are avoided. The plates are separated by spirals made of special steel, the pressure for the joints between the plate and the channel separating it from the adjacent plate, being supplied by compressing laterally against the springs. Thus at *C*, Fig. 4, are shown a number of vertical plates separated by channels and steel spirals. In order to tighten the joints, the bolts at the right are drawn up, compressing the springs as shown at *E*. These are wound of comparatively heavy wire in the neighborhood of $\frac{3}{8}$ or $\frac{1}{2}$ in. diameter at about one turn per inch. They are made of special steel. The construction here shown places the spirals in the partitions occupied by the furnace gas. Other constructions, however, involve the relative location of channels, plates and spirals so that the spirals are carried in the cooler air spaces only. For very high flue-gas temperatures the latter plan is advisable.

Plates composing the preheater are free to move with expansion, contraction, etc. Furthermore, such a construction makes it possible to renew one or more plates without dismantling the preheater. On slacking up the bolts that control the spiral pressure, as at *C*, Fig. 4, old sheets may be lifted out and new ones inserted. Heaters of this type are both installed and in order in this country.

A plate type unit, shown in Fig. 6, contains sheets

TABLE I—HOWDEN-LJUNGSTROM AIR PREHEATER TEST WITH WATER-TUBE BOILER.

At North Metropolitan Electric Power Supply Co., Ltd., London, Willesden Station.

	Test Without Air Preheater 11/10/23		Test With Air Preheater 1/11/23
Duration of trial in hours	8		7
Calorific value as fired, B.t.u.	10,470		10,850
Calorific value net—that is, after hydrogen correction, B.t.u.	10,040		10,410
Riddlings—fine coal, lb.	183		295
Coal consumed per sq.ft. grate area per hour, lb.	29.4		28.7
Average gauge pressure lb. per sq.in.	189		196
Superheated steam temperature, deg. f.	580		587
Feed water average temperature, deg. f.	108		102
Temperature of air inlet to fan, deg. f.	...		64
Temperature of air leaving preheater, deg. f.	...		474
Temperature of flue gases at boiler damper, deg. f.	550		595
Temperature of flue gases leaving preheater, deg. f.	...		269
CO_2 at boiler damper	8.9		10.3
Efficiency based on gross calorific value, per cent	74.56		84.0
Coal Saving based on gross calorific value, per cent		11.2	
Efficiency based on lower calorific value, per cent	77.7		88.1
Coal saving based on lower calorific value, per cent		11.8	

that are diagonally crimped as indicated at *I*, in Fig. 4. A feature is that the through bolts are hollow, so that they may be utilized for cleaning the interior by means of steam jets. This is built by the Rotator Maschinenfabrik und Apparatebau, of Germany. A number of units may be utilized, so that the complete installation

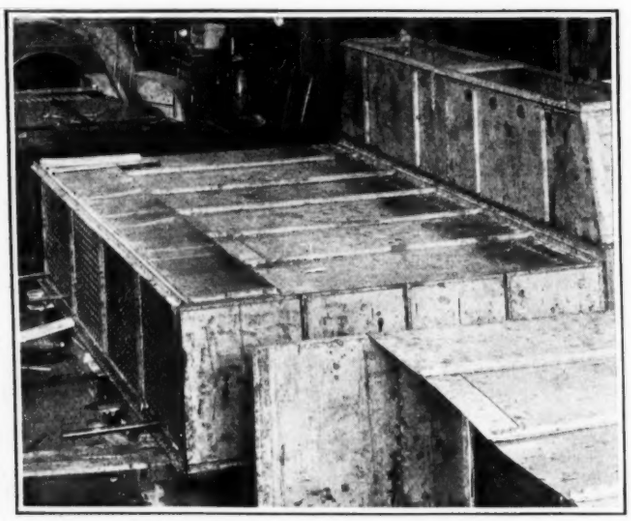


Fig. 9—Tubular units under construction by the Buffalo Forge Company

conforms to the desired shape. This system was designed by Eugene Haber.

Frederick Ljungstrom, of Sweden, has developed a novel type of air preheater as an accessory to his turbine-driven locomotive. On account of the low heat exchange in tubes near the locomotive stack, the heating surface of the boiler here was reduced, making the preheater a logical step. The final result of the experiments was the evolution of a heat exchanger, as shown at *F* in Fig. 4. The summary of a test appears in Table I.

Instead of transferring heat through sheets or tubes, heat is here absorbed by slowly revolving corrugated plates, which then travel into the path of the air to be preheated. Heat is thus taken up from the escaping stack gases, whose path is indicated in the left of the figure, and is given up to the downward traveling air

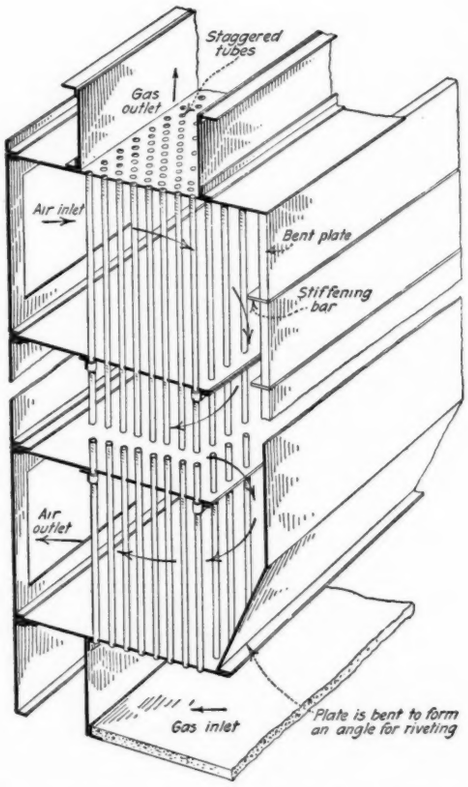


Fig. 10—One type of the Babcock & Wilcox Company

Plates of casing have edges bent to form angles for riveting, with stiffening bars or plates sometimes added.

through which the heated element passes, so that it is actually exchanged instead of being transferred through metal partitions.

The rotating element is illustrated in Fig. 7. Corrugated sheets, placed concentrically, are divided by partitions into sectors. The upper radial arms shown in the figure indicate the sectors into which the heat-transferring surface is divided. Each radial arm is equipped with a packing piece which maintains close clearance to the flat stationary plate which is placed above it in the preheater. Similar close clearances are provided below.

Leakage of air into the flue-gas chamber is restricted by the close clearances with which each radial sector is equipped, although a small amount of air is necessarily carried into the gas chamber by the revolution of the drum, and also a small amount of warm gas may be carried into the air chamber on account of being entrained in the corrugated rotating elements. Most of these leakages are of negligible magnitude since the gases travel approximately 800 ft. per min., while the drum moves at four revolutions per minute. Below the drum is a radial pipe with nozzles, which may be utilized for cleaning the rotating element by means of steam jets when required.

The forced-draft fan and the induced-draft fan both operate on the same shaft. To this shaft is belted a

device for driving the rotating drum. The fans may be so proportioned that a balanced draft is maintained in the furnace under all conditions. The fans are ordinarily designed individually for each installation, and also contain adjustments whereby the angle of the vane may be altered to suit the local conditions that prevail.

A large amount of heat-exchanging surface may be maintained in a comparatively small space, and the necessity for a large number of welded, riveted or otherwise tightened joints is obviated. The separation of the corrugations into sectors does not require a high degree of tightness. The rotating element contains no internal bearings or shafts exposed to hot gases, but rests on externally mounted rollers which are surrounded by the fresh air and are accessible from the outside.

A tubular unit where steam does the preheating, shown at *G*, Fig. 4, is described in the Aug. 1, 1924, issue of *The Engineer* (London). This type, the "Weldex," is manufactured by the Victoria Tube Co., Ltd., of England. It is of welded tubular construction, the distinguishing feature being small gooseneck pipes, forming expansion joints between the inlet manifold and the large heating tubes, as at *H*. A unit is made up of several elements, each of which consists of a single row of heating tubes.

Cast iron composes the unit in Fig. 8, manufactured by E. Green & Son, of Wakefield, England. On account of anti-corrosion properties, this is in some instances preferable to rolled metal. A number of elements, such as that shown at the lower right-hand corner, each consisting of four rectangular tubes, may be grouped in a number of ways in order to give the desired form of air preheater. A flat type is illustrated, in which the gases enter at the left, make one pass upward around the tubes and then another pass downward at the right. The air is supplied at the left, through the interior and the rectangular tubes, and also from the right-hand side, leaving from the middle.

The four tubes are cast in one piece with a flange 10x5½-in. at each end, being 2½ in. long, 4 in. deep, 1 in. wide and 1 in. apart. A complete element contains 9½ sq.ft. of external and 8.3 sq.ft. of internal heating surface. A converging mouthpiece is supplied at the entering end, outside of each tube in order to prevent undue eddies of the air. The flanged elements are machined or ground, and the intermediate pairs are bolted together. Each element weighs 80 lb., and its volume is approximately one cubic foot.

A number of tests indicate that the heat transmitted per square foot of heating surface per hour per degree difference in temperature, between gas and air, varies from 1.8 B.t.u. for an air velocity of 1,000 ft. per minute, to 3.3 for an air velocity of 2,500 ft. per minute.

Cleaning can be done from the outside with steam or compressed-air pipes, by means of jets which may sweep the entire surface.

The tubular preheater, Fig. 9, is under construction by the Buffalo Forge Co., which has installed three tubular units at the Crawford Avenue Station of the Commonwealth Edison Co. Each contains approximately 10,000 sq.ft. of heating surface in the form of 3-in. boiler tubes 14 ft. long. The flue gases entering from the economizer pass vertically upward through the tubes and to the induced-draft fan, while the air taken from inside the building passes around the tubes with suitable baffles to direct its flow, entering at top and leaving at the bottom, being drawn through the preheater by the forced-draft fans, from which it is delivered to the windboxes.

The preheater casings on this installation are ¼-in. plate, made up in panels with angle-iron framing, so that through bolts can be used for connecting the panels. The lower chamber has a hopper bottom for draining the water used in cleaning the tubes.

Based on the entering flue gases having a temperature of 325 deg. F. and a volume at this temperature of 76,000 cu.ft. per min., each preheater will heat the volume of air required for the same boiler through a temperature range of about 72 deg., or a heat transmission of 3,900,000 B.t.u. per minute.

The Commonwealth Edison Co. has found that any accumulation of soot in the tubes may be removed by a water jet, and the vertical tube arrangement is intended to facilitate this.

Tests on a Babcock & Wilcox tubular unit in the Calumet Station appear in the August, 1924, Report of the N.E.L.A. Prive Movers Committee. The effective surface is 8,954 sq.ft. made up of 2-in. vertical tubes, 14 ft. 6 in. long, inside of which the gas passes. The guaranteed performance is given in Table II.

TABLE II—GUARANTEED PERFORMANCE OF B. & W. TUBULAR PREHEATER AT THE CALUMET STATION

Cu.ft. gas per min.	82,600	64,800
Inlet gas temp., deg. f.	340	315
Outlet gas temp., deg. f.	282	257
Cu.ft. air per min.	50,300	40,800
Inlet air temp., deg. f.	70	70
Outlet air temp., deg. f.	136	136
Boiler evap., lb. per hour	150,000	125,000

A plate-type unit by the same manufacturer of 9,000 sq.ft. is installed on another boiler. A representative unit of this manufacturer appears in Fig. 10.

The Green Fuel Economizer Co. manufactures units with steel or cast-iron tubes. A special inlet gland at the tube sheet provides a graduated inlet, and contains an asbestos washer to secure airtightness between tube and sheet.

A preheater wherein bled steam heats the air is installed at the Saginaw River Steam Generating Plant of the Consumers Power Co. It is of cellular copper construction, in three stages, manufactured by the American Blower Co. Air passing from the forced draft fan will be raised from about 80 deg. F. to 300 deg. The first stage utilizes drained hot water; the second bled steam at about 15 to 20 lb. abs. and the third, bled steam at 80 to 100 lb.

Other manufacturers are developing preheaters which will be described when information is available.

During the heating and cooling processes in the production of steel ingots or forgings, various stresses are set up, which may reach a point where fractures occur in the material. At the moment when such fractures occur, there is generally a severe shock and a ringing noise, or "clink." Where the fracture is entirely within the forging, this clink is practically the only method of detecting defective forgings. An automatic watchman to secure evidence of any such clink is described in the November 7 issue of *Engineering*. According to that paper, Messrs. C. A. Parsons & Co., Ltd., in connection with the Cambridge Instrument Co., Ltd., have developed an instrument called the clink detector, which, when attached to a forging during the heating and cooling processes, gives an autographic record of any shock that occurs. The instrument is sufficiently sensitive to record an ordinary hammer blow.

Making Electrical-Machinery Tests in Industrial Plants

Reasons for Making Tests—Examples of Conditions Discovered by Tests—Forms on Which to Record Motor-Test Data—Selection of Instruments Best Suited to Making Tests

By J. ELMER HOUSLEY
Electrical Engineer, Aluminum Company of America, Alcoa, Tenn.

IN INDUSTRIAL plants and in power houses the operating engineer has found his work to include an ever-increasing number of motor drives. In order to discover what is going on inside a motor, it is necessary for the engineer to include a knowledge of electrical testing instruments in his personal equipment and to secure a few well-chosen electrical meters to go along with his other metering equipment.

An electric motor does not give any audible signals of distress, and when the visible evidence, smoke, occurs, it is often too late to save a big repair bill for a new winding. Nor is this the only loss that occurs, because the overload that burned out the motor was probably taking 25 per cent more power from the line, for some time, than the load should require. In the mill it does not take many motors carrying unnecessary loads to increase the power bill or decrease the coal pile greatly.

MOTOR TEST RECORD

H. P. _____ MANUFACTURER _____
TYPE _____ FORM _____ AMP. _____
R. P. M. _____ SERIAL No. _____ RECORD No. _____
DATE _____ LOCATION _____ DRIVE _____
CURRENT TRANS. RATIO _____ CHART FEED _____ INS. PER HOUR

V. M.	Volts	A. M.	Amps.	K.V.A.	W. M.	W. M. Constant	KW.	H. P.	P. F.	R.P.M.	FREQ.	REMARKS

Motor-test data record card

Motor troubles can be corrected if they are known to exist, and that can be found out only by testing them regularly. The cause of the overload may result from mechanical friction due to poor bearings in the drives, equipment out of alignment, variations in process material being ground or mixed, pump thrust due to suction intakes being plugged, using too heavy grease in line-shaft bearings in cold weather and many other causes that may be found upon investigating the driven machinery.

Many surprising conditions are brought to light by means of a motor test, as was in the case of a motor drive on a cinder-removal pump operating in connection with a sluicing outfit in a large power house. The motor oiler reported that this motor was excessively hot, and a complete test was immediately made. The input to the 75-hp. motor averaged 142, or about 190 per cent full load. The reason the motor had not burned out was that it ran only four times a day for thirty to forty-five minutes at a time, and also that the oiler reported the motor promptly and it was tested immediately. To the trouble, it was only necessary to take off the guard over the coupling. The coupling on the pump shaft had loosened and allowed the pump thrust to push the impeller against the case, thus creating a friction brake. The pump was an open-impeller belted type, and the thrust bearing was on the outside of the coupling.

Tests on Pumps in Parallel

There are errors of operation in connection with centrifugal pumps which may be sufficiently demonstrated to the operator only by means of a motor test. At one time an operator in charge of a battery of evaporators ran two pump units in parallel continuously, supplying water to the condensers. The pumps were designed to operate one at a time in order to insure continuity of service. The operator argued that more water was being pumped using two pumps and that if no more water was being pumped the extra motor took an inappreciable amount of power. A rough weir was constructed to gage the water from the cooling towers, and motor tests were made on single-pump operation and also with both pumps in parallel. The test showed that with one pump running the water was, let us say, 100. With two pumps in operation the flow was slightly less than 110, with the input to the single pump as 100. The sum of the input loads using both pumps was 170, which afforded a chance for a nice saving.

Again, motor tests help in improving the layout of equipment that has been designed with lack of accurate operating data. In one instance a pumping unit designed for intermittent operation was installed with a 100-hp. motor. A batch of fluid was pumped out of the suction tank in five minutes and twenty minutes elapsed between batches. A motor test showed that the motor carried full load for 4½ min. and ran at 20 per cent load, idle and without fluid in the pump, for 15 min. Instead of depending on an operator to shut down the pump every twenty minutes, it was decided to cut down the diameter of the pump impeller as the static discharge head was relatively low. One-half inch was cut off at a time and a motor test was made after each cut. After two cuts the pumping time was increased to 17 to 18 min. and the idle time to 2 to 3 min., and the load was decreased to 40 hp. input. As a result a 40-hp. motor was installed.

It is a good plan to set a regular time to go over all the motors in the plant and test them, usually once every six months. However, this will vary according to the operating condition under which the equipment works. When there are any indications of trouble, such as an unusually hot motor, low speed of induction motors and either high or low speeds of direct-current motors or excessive sparking at the brushes, the motor should be tested immediately to find where the trouble is located. The figure shows a form that is being used for recording motor test data in a large industrial plant. Under the headings "V. M.," "A. M." and "W. M." are recorded the actual readings of the voltmeter, ammeter and wattmeter respectively. In the columns headed "Volts" and "Amps." are recorded the correct volts and amperes as obtained by multiplying the meter readings by the proper multiplier or correction factor. Column "W. M. Corrected" is for use when a correction factor is employed to obtain the correct watts from the wattmeter reading.

Occasionally, the tests will show up some defect in the motor itself or in the feeder circuits supplying the motor. In a later article will be given the details of how to identify some of these troubles which are sometimes difficult to locate. A long experience indicates, however, that only about 10 per cent of motor failures result from internal defects, the remainder being caused from trouble in the driven machinery, and this fact is an eloquent tribute to the general reliability of electrical equipment.

One subject that is being considered carefully by the public utility companies and that should be of interest to the operating engineer, is power factor. If an induction motor of 10 hp. and above has been properly selected for its load conditions, the power factor should be 80 per cent better. When a motor-test survey is made it should include particular attention to the question of power factor. In making a complete load test, sufficient instruments will of necessity be used and the power factor may be readily determined from readings obtained.

Low power factor introduces several undesirable conditions because of the idle current present on the power lines, in transformers and generators. It overloads the power lines, causing additional heating of cables, transformers and generators as compared with the same load carried at a better power factor. The line drop or loss of voltage is greater at low power factor than at high, because this loss is proportional to the line current. The regulation of transformers and generators, which means the voltage variation between no load and full load, is increased, which gives a lower voltage and greater fluctuations of voltage at the motors, when the motors operate at a low power factor.

Another important use of testing meters is for the determination of load conditions in group drives. Where a single motor is used for a number of important drives, it is necessary to watch closely the addition of any new machines to the drive in order to prevent overloading of the motor and possible damage to it. Such a failure may tie up a large amount of production machinery. Trouble of this nature may be avoided by testing the motor each time equipment is added to the drive.

The most perplexing problem for one about to buy testing equipment is what to buy first and how many instruments are required for a given plant equipment. In equipping various plants from small alternating-current and direct-current installations having 10 motors up to a plant having 1,500 motor drives, the writer used a voltmeter and ammeter in a small direct-current plant. In a small alternating-current plant a cable-type current transformer, split-type with calibrated leads, and ammeter was used with a voltmeter. With regard to the range of the instruments, this should correspond to the voltage of the circuit and the current of the largest motor. In the largest plant about 50 instruments and instrument transformers were used.

In the table the instruments required for various tests are indicated. Although this table by no means represents all the tests that may be made in an electrical installation and the meters used for these will vary with the fancies of the engineer, nevertheless the suggestions given in the table will serve as a guide in choosing a set of test instruments. The details as to how the meters are connected, used, records kept and what the results mean after they are secured will be given in future articles.

TABLE OF EQUIPMENT REQUIRED FOR MAKING DIFFERENT KINDS OF TEST ON ELECTRICAL MACHINERY

Tests For	Speed Counter	Compass	Voltmeter Type	Ammeter Type	Wattmeter Type	Current Transformers	Potential Transformers	Megger	Rotating Standard Wattmeter	Frequency Meter Type	Power-Factor Meter Type
Direct-current											
Voltage			Per. Mag.								
Current				Per. Mag.							
Kilowatt load			Per. Mag.	Per. Mag.	Optional						
Overloads	Any type		Per. Mag.	Per. Mag.	Rec.						
Speed	Any type		Per. Mag.	Per. Mag.	Optional						
Heating			Per. Mag.	Per. Mag.	Optional						
Faults in windings and connections	Any type	Small	Per. Mag.	Per. Mag.							
Voltage drop			Ind. or Rec.								
Line polarity			Per. Mag.								
Insulation			Per. Mag.					Or any make			
Kilowatt-hour meters			Per. Mag.	Per. Mag.	Optional						
Alternating current											
Voltage			Dyn.				*				
Current				Dyn.		One					
Kilowatt load			Optional	Optional	Ind. or Rec.	Two	*				Optional
Kilovolt-ampere load			Dyn.	Ind. or Rec.	Optional	Two	*				Optional
Power factor			Optional	Optional	Optional		*				Ind. or Rec.
Frequency	Any type						*			Any type	
Overload	Any type		Dyn.	Dyn.	Ind. or Rec.	Two	*				Optional
Underload	Any type		Dyn.	Dyn.	Ind. or Rec.	Two	*				Optional
Speed	Any type										
Heating	Any type		Dyn.	Dyn.	Ind. or Rec.	Two	*			Any type	Optional
Faults in windings and connections	Any type	Small	Dyn. & Per. Mag.	Dyn. & Per. Mag.			*				
Single-phase operation			Dyn.	Dyn.			*				
Insulation			Per. Mag.					Or any make			
Kilowatt-hour meters									Any make		

* Above 550 volts potential transformers required.
Except where stated otherwise, indicating-type meters specified.
Ind. = Indicating; Rec. = Recording; Per. Mag. = Permanent Magnet; Dyn. = Dynamometer.
Current transformers should be of the split type so that they can be connected in the circuit without interrupting the line.

The Utilization of Heat Head

By A. G. CHRISTIE
Professor of Mechanical Engineering, Johns Hopkins University

THE ultimate purposes of a modern steam-power station are: First, to generate the greatest quantity of high-pressure steam from a given weight of fuel; second, to utilize to the fullest extent commercially possible the heat head of this high-pressure steam. The production of steam from fuel has been given close study of recent years and this subject is now quite well understood. The objective of high boiler-plant efficiency is clearly defined and kept in mind in designing steam stations. Economizers and air preheaters are employed where economic conditions warrant their use. Heat-balance studies have resulted in the wide use of bleeder heaters on the main turbo-generator units to heat the feed water, and practically all secondary sources of waste heat are now also used for this same purpose. In general it can be said that the question of fuel economy in steam generation is well covered by the station heat-balance studies.

Heat-balance studies have, however, frequently been made without full consideration of the second purpose of the power plant, namely, the utilization of the heat head. Usually, when an engineer satisfies himself that he has discovered the maximum amount of waste and secondary heat and has returned this heat to the boiler, he is likely to feel that his plan offers the best solution of the problem of station economy. He has recovered drips, used auxiliary exhaust steam, recovered the heat from steam-jet air pumps, etc., etc., and has even bled his main units. At first thought this would seem to be the ultimate of plant design. However, the performance of certain new steam stations where heat head has also been given close study, warrants the statement that a heat balance of the type described may be misleading and may not provide the most economical station for the given set of conditions.

THE author needs no introduction to *Power* readers. The heat studies that he has made as a consultant in the design of several large stations have led to the conclusions set forth. They are applicable especially to the big plant, but may not be expedient in some cases for commercial or operating conditions. Inasmuch as there may be differences of opinion concerning some of the views expressed, they afford a field for profitable discussion.—*Editor*.

What is meant by "heat-head"? The idea can be presented by considering a parallel case. Take the case of a supply of water on a high plateau which can be piped in a penstock down to a power plant at sea level. There will then be a certain hydraulic head available to produce mechanical energy. Water can be withdrawn at various heights above the power plant for useful purposes such as irrigation, etc. Unless this water is passed through a small waterwheel at the point where it is withdrawn from the penstock, its hydraulic head is lost so far as the production of power is concerned.

In the case of high pressure and highly superheated steam the heat head may be considered as the heat available from adiabatic expansion from the initial conditions at the superheater outlet down to the final exhaust pressure or vacuum. The superheater may be considered the "high plateau" for the steam and the exhaust pipe or condenser, the "sea level." As in the case of the water steam may be withdrawn from the engine or turbine between these two levels for some commercial purpose such as for heating feed water, for warming buildings or for some industrial process. If there are economic needs for heat at various pressure levels, it is good engineering to divert such portions of steam as are required for these purposes, provided the maximum amount of power has been developed in an engine or turbine from the heat head available between the initial conditions and the pressure at which it is withdrawn. The power-plant designer should therefore see that no steam is applied to any such process without first converting into mechanical energy the greatest possible heat head.

Heat head for any conditions can be readily found from a Mollier diagram. The total heat of one pound of steam at the initial pressure and superheat is first noted and a constant entropy line followed to its intersection with the pressure line corresponding to the final pressure. The total heat of this point is then read. The difference between the initial and final total heats is the "heat head."

The use of steam-driven auxiliaries to furnish steam to heat feed water is a familiar example of waste of heat head. Such auxiliaries generally convert only a small portion of the heat head into useful work owing to their inherently low efficiency. The feed water may be heated in steps to the same temperature in a series of heaters furnished with steam bled from several stages of the main unit. The main turbine will have a high efficiency and will convert the maximum amount of the heat head of such bled steam into work. The high-pressure portion of most large modern turbines using superheat is appreciably more efficient than the low-pressure portion. The practice of bleeding steam for feed-water heating therefore tends to raise the over-all efficiency of the turbine as well as that of the station as a whole. The fact that bleeder heating may be done at stages below atmospheric pressure tends toward still further utilization of heat head and higher over-all station economy, for a portion of the feed-water heating may be done with lower-pressure steam than is usually available from steam-driven auxiliaries.

Bleeding has been so well discussed elsewhere that it needs no further consideration in this connection. The advantages accruing from the utilization of heat head are quite evident in this case.

Steam-jet air pumps are used in many plants to produce vacuum. Usually, these are two-stage affairs, with heaters after each stage to condense the steam used in the jets. The feed water passes through these

heaters, and hence the jets are used as a means for heating feed water. Frequently, the steam pressure from the main header to these steam jets is lowered by reducing valves. Very little of the available energy of the steam is used by the jets to do the useful work of compressing the air and vapor withdrawn from the condenser; hence it may be said that the heat head of such steam is utilized very uneconomically.

If the same steam that is used in each jet is passed through the main unit and bled to heat feed water at pressures corresponding to the pressures in the stage heaters of the steam-jet pump, it will be found that a considerable amount of power can be produced at the turbine coupling even after allowance has been made for the lower heat content of the steam so bled from the main unit. This power, after allowance for main generator and motor losses, will generally be found to be about twice the amount required to drive a reciprocating dry-air pump of modern design to do the same work as the steam jets. The power not required by such dry-air pump should be capitalized at the full value of the main generator output in arriving at the economics of the choice between steam jets and reciprocating dry vacuum pumps. Furthermore, the power required by a reciprocating dry vacuum pump tends to decrease at very high vacuums, while the steam required by steam jets stays the same. This reasoning leads to the conclusion that the use of a reciprocating dry vacuum pump provides for greater utilization of heat head than the use of steam jets and hence results in greater station economy. The motor-driven reciprocating dry vacuum pump has been installed in several new stations as having the highest over-all efficiency.

Steam-jet ash conveyors are used in many plants. They provide a clean, cheap, easy way of handling ashes. However, the heat head of the steam is practically wasted. The steam itself is lost and additional makeup must be provided for the boilers, which throws an extra load on evaporators when used. Furthermore, the heat in this steam is also wasted, as no provision can be made for its recovery. This disturbs the heat balance. Many mechanical devices can be used to handle ashes at a power consumption that is relatively low as compared with the wasted heat head of the steam used in a jet conveyor. The first cost of these devices may be more than that of the steam-jet conveyor, but this added expense may be justified by the power and heat saving resulting from the better utilization of the steam.

Frequently, high-pressure evaporators are used in steam stations for providing makeup. In such units no mechanical work is developed from the steam used. This practice cannot be justified from the viewpoint of utilization of heat head. It is possible to provide low-pressure evaporators of the same capacity in connection with bleeders on the main units, which will provide for a maximum utilization of the heat head.

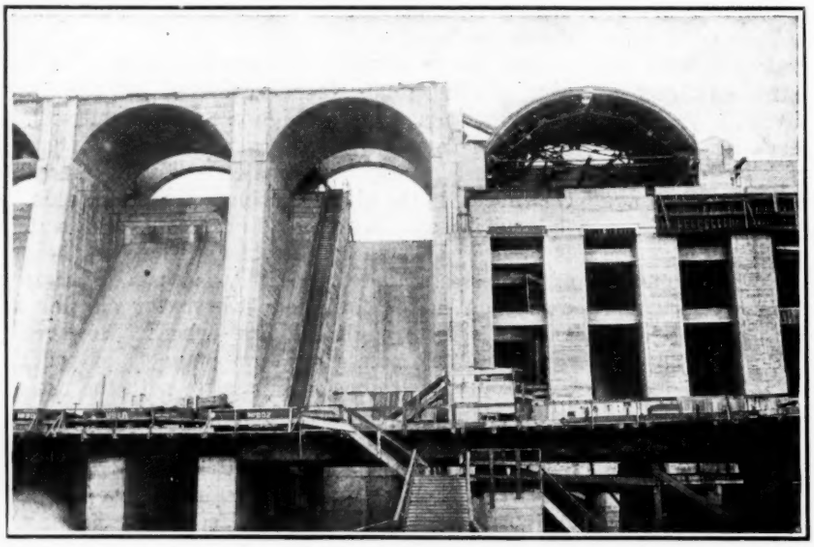
Another offender in wasting heat head is the soot blower. In most modern high-pressure stations this is furnished either with high-pressure steam from the superheater outlet or with such steam delivered through an orifice at a lower pressure than in the boilers. In any case none of the heat head of the steam is utilized. It should be possible to design soot-blower elements to use steam at a slightly lower pressure than is now considered necessary and to provide such steam from a bleeding point at one of the early stages of the main unit. This would provide for the maximum utilization of the available heat head. This question of soot-blower steam is of great importance to the engineer, for operating tests have shown that in average plants this runs from 1 to 2 per cent of the total steam generated for the boiler alone.

Multi-stage impulse turbines lose from 1 to 2.5 per cent of the total steam furnished at the throttle, through leakage at the high-pressure gland seal. This leakage is small when the glands are new, but tends to increase rapidly as vibration and wear increase the clearances, in the gland packings. Generally, this steam is used in some heater or other device where its heat is recovered in the feed water. The only heat head of this steam that is utilized, is that resulting from expansion in the first-stage wheel, for all this steam should pass through the first wheel. However, this work is small unless the first stage is of the Curtis two-row type. It should be possible with the use of the water gland outside of the high-pressure steam packing, which is now becoming standard practice, to pipe this gland leakage at one or more pressures to lower stages of the main unit where its remaining heat head can be fully utilized. The equivalent feed-water heating from the gland steam may be more economically done by bled steam from the turbine at or about atmospheric pressure. Objections may be raised to such practice on the ground that it is inadvisable to introduce high-temperature steam in the lower stages of the main turbine. However, in view of the fact that the over-all economy of the turbine might be increased possibly as much as 1 per cent by such use of this steam, it would seem that further attempts should be made to modify present designs so that it may be utilized in the manner indicated.

Utilization of Continuous Blowdown

A case involving the waste of the heat head in hot water might also be mentioned. The boiler blow-down in most stations is discharged directly into a sump. As this water leaves the boiler at a temperature corresponding to the boiler pressure, its heat head is absolutely wasted when it is blown free to a sump. Operating men always tend to blow down their boilers for longer periods than is necessary, which practice further increases this loss. Continuous blow-down has been proposed in the place of intermittent blowing-down. Calculations will show that continuous blow-down combined with multiple-effect evaporators will provide practically all the distilled water needed for makeup in the average power plant. Furthermore, a large percentage of the heat leaving the boiler in the blow-down water may be recovered by passing the boiler feed water through the final evaporator condenser.

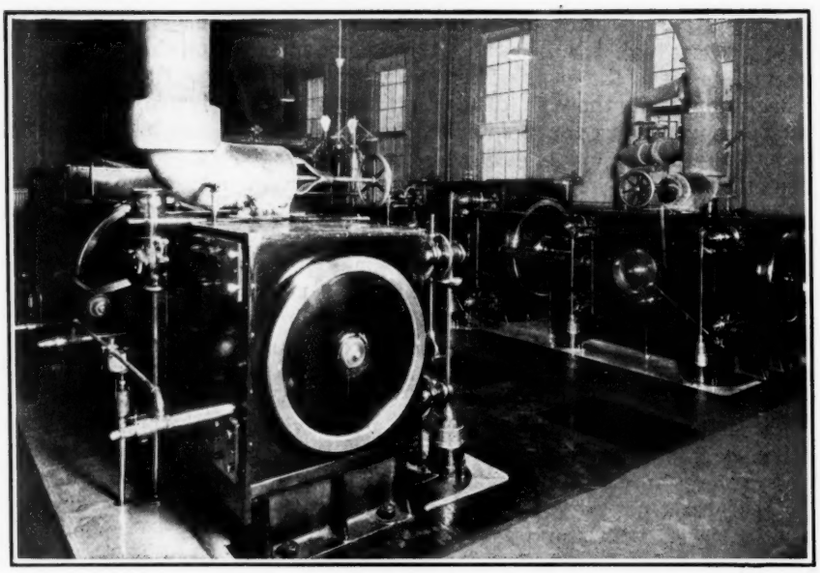
Still other examples might be cited, but these will serve to bear out the point that certain practices do not provide for the full utilization of heat head of the steam used. Of course there may be financial, operating or other special considerations that make it desirable and even economical to use such equipment as that to which objection has been raised. In most central stations careful consideration has been given to these devices in connection with the heat balance, and in general the heat units are carefully conserved. Yet, as has been just shown, this conservation of heat, while satisfying the heat balance, may not lead to the design of the most economical plant, for the available heat head has not been fully utilized.

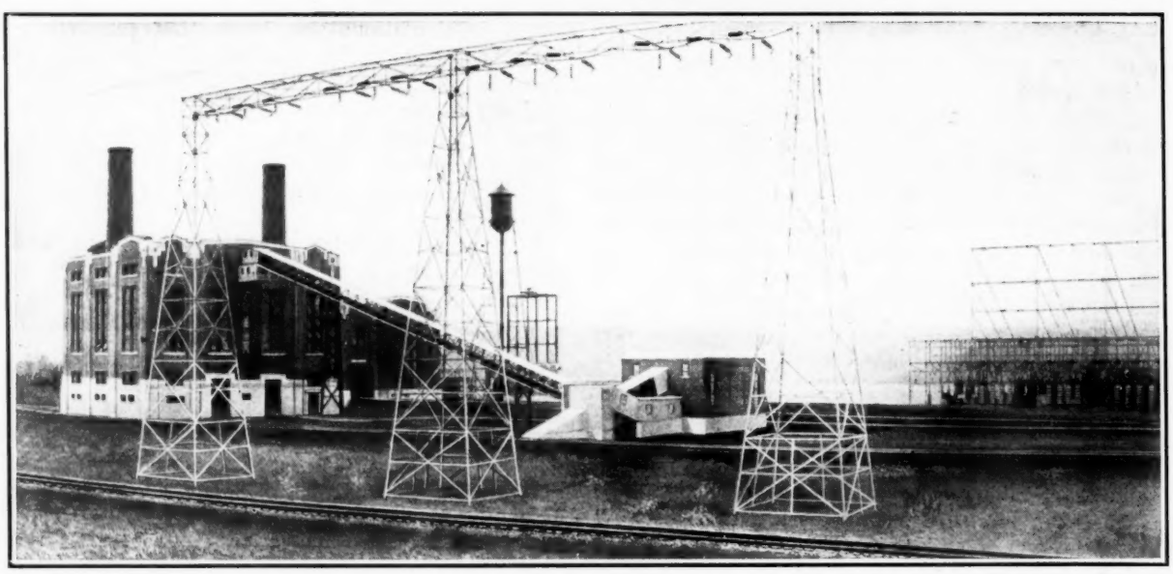


Left — Power-house end of Wilson Dam, Muscle Shoals, as it appeared on Nov. 3, 1924

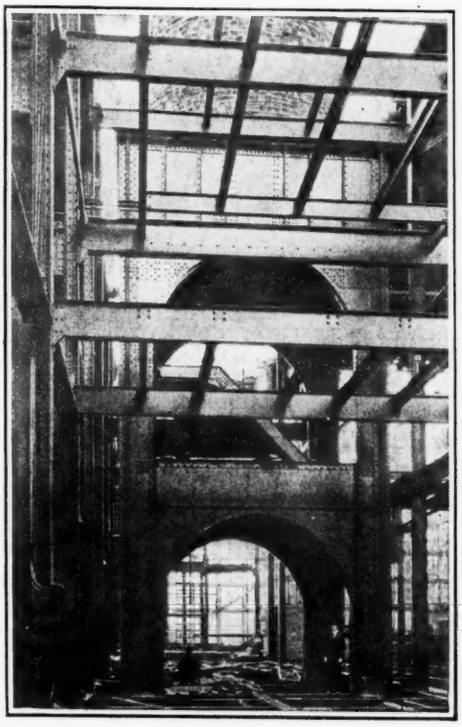
Right — A 1,200-hp. twin-tandem compound engine in service at the Clark Thread Co., Newark, N.J., since 1888

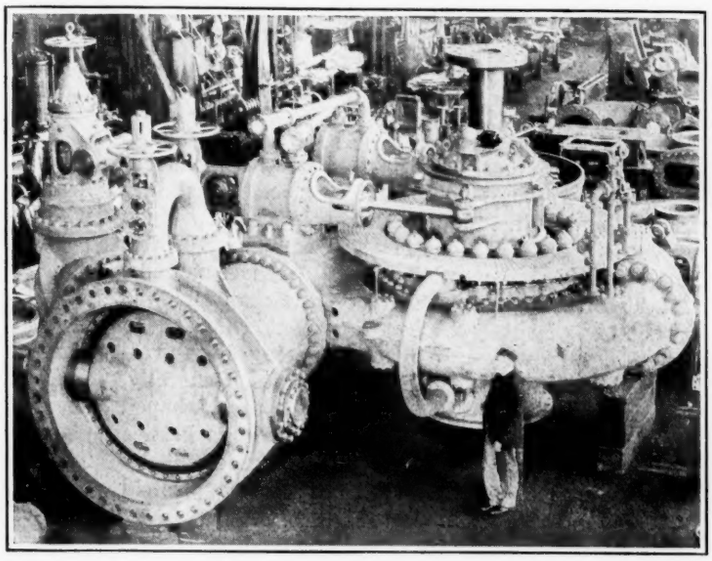
Below — Recently completed Grand Tower station of the Central Illinois Public Service Co. Present capacity 40,000 kw. in two units utilizing steam at 350 lb.



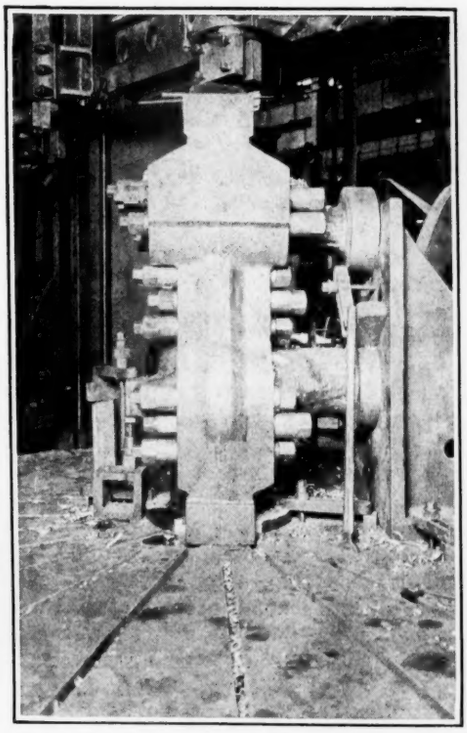


Below—A 55-ft. steel platform supporting stack independently of station structure at new Fairmont pumping station, Cleveland



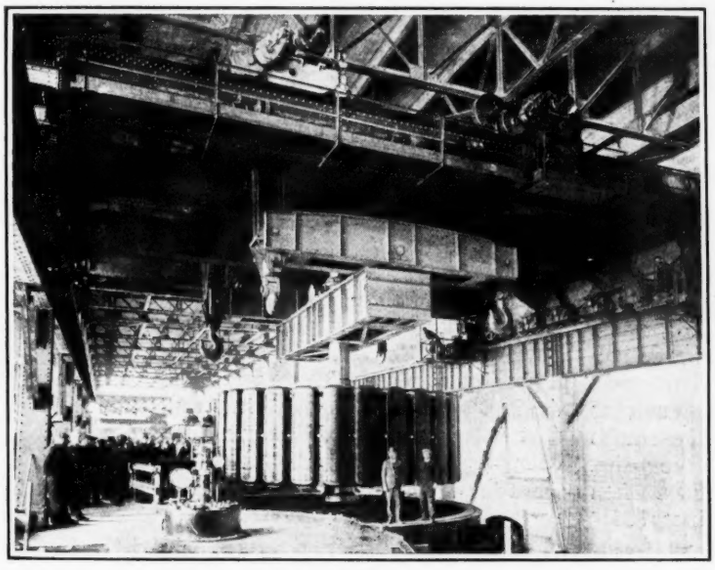


Butterfly valve and 35,000-hp. Frances type turbine to operate under an effective head of 875 ft. in the Oak Grove plant of the Portland Electric Power Company



Casing of 1,200-lb. Weymouth turbine in boring mill. This side view indicates small rotor diameter

Below—Lifting the rotor of a 70,000-hp. generator with two 200-ton cranes at the Niagara Falls Power Co. Rotor weighs 399 tons; total load on crane rails about 550 tons



Modern Power-Plant Equipment Reflects Changed Conditions

By P. W. SWAIN*

EVER since James Watt built his first steam engine, power-plant equipment has been constantly changing. Watt depended almost entirely upon the vacuum to get work out of the steam, his throttle pressures being of the order of two or three pounds. Richard Trevithick put pressures on the map and was the instigator of many a merry content run at the English mines between his non-condensing high-pressure "puffers" and Watt's condensing engines. Generally, Trevithick carried off the honors. The haystack-shaped boilers of that day were little more than huge kettles built of crude patches laboriously hammered out by hand. The furnaces were generally built of rough field stones.

Jumping from the days of James Watt to those of 1884, four decades ago, the Corliss engine had already reached a high state of development. With 70 lb. pressure at the throttle and turning over at the leisurely rate of 70 r.p.m., this machine seemed the embodiment of all that was fine and beautiful in the mechanical world. Using saturated steam, it had no high temperatures to contend with. The moderate pressures and low speeds simplified the problems of balance and strength of parts. Cast iron and low-carbon steel met all requirements perfectly. Lubrication was a simple problem, as was the packing of glands.

THE growth of the oak from the acorn is no more wonderful than the transition from the crude engines and haystack boilers of Watt and Trevithick to the highly organized power plant of today, so complex that no individual mind can encompass all the known details of its design. With interesting sidelights on the underlying forces controlling development, this article reveals in succession the plants of Watt's day, 1884, 1904, 1914, and finally that of 1924.

The only evidences of electricity in the power plant were occasional sparks of "static" jumping from the huge leather belt that delivered the power to the mill. On top of the engine majestically rode the old Watt governor with two flyballs and no center weight.

Except for the steam main and the throttle valve, the operating room was practically bare of other equipment. The whole layout was well within the comprehension of any bright schoolboy who could use his eyes.

In sharp contrast to the engine room, which was generally dressed up for visitors, was the boiler room, where toiling and sweating individuals threw the coal, scoop by scoop, into the narrow space between the grate and the shell of a small horizontal return-tubular boiler. This boiler was built of wrought iron with a steam dome to eliminate some of the water and a safety valve of the lever-and-weight type. Steam gage, water column and injector completed the equipment. There were no mechanical stokers, no meters or other instruments (except a pressure gage) and no fans. The smoke (and there was plenty of it) went up a square brick chimney and spread like a pall over the landscape when business was good. No smoke meant no business!

In a pinch the boiler could evaporate 3 lb. of water per square foot of heating surface. The boiler was squeezed as close to the fire as possible to "catch the heat." The fact that the furnace walls carried the whole weight of the boiler disturbed no one.

Coal—real coal at that—could be laid down at most plants for $2 a ton. At the mine it cost about 90 cents. No one knew or cared about the evaporation per pound of coal. So long as steam was kept up no questions were asked.

About this time or a year or two earlier a few engineers began to think about cutting down the cost of a plant to get a given power. That meant more speed. The problem was attacked by Porter, Allen and others. Out of their studies came the high-speed automatic slide-valve engine which so astonished the old Corliss operators. Byproducts of this work were the Porter flyball governor with center weight and the shaft gov-

Out of their studies came the high-speed automatic engines met the demand for low first cost (a real engineering consideration) they did not fully meet expectations in the matter of efficiency. Hence the attempt to speed up the Corliss and the final development of four-valve engines with non-releasing gear. These obtained high speed without sacrificing the clean-cut indicater diagram of the Corliss. Meanwhile there was steady progress in boiler design. Pressures were raised slightly in some cases. The steam dome, with its weakening effect on the shell, was removed and replaced by a "dry pipe." The pop safety valve replaced the lever and weight.

Take another jump from forty years ago to twenty. Further marked changes had taken place. The outstanding change from twenty years before was the growth of the central station. In 1884 the electrical generation of power was a decided novelty. In 1904 the central stations had become a huge industry, although their load was largely confined to lighting and traction.

Although a few turbines were in operation, the mainstay of power generation in central stations as well as in isolated plants was the reciprocating engine. Very few engineers, brought up in the school of the slow-speed reciprocating machinery, were willing to take a chance with a "freakish" new device for generating power. The Corliss, long since perfected, still occupied a prominent place. There were many compound Corliss engines where economy was sought. Non-releasing four-valve engines of various types (both simple and compound) were in general use. High-speed engines were in particular demand for direct connection to generators.

In many of the central stations of the day vertical cross-compound engines and angle-compounds could be seen direct connected to huge "dynamos" with large

*Assistant Editor of *Power*.

numbers of poles. The most powerful reciprocating units of that day were the twin angle-compound engines installed in the Fifty-ninth Street Interborough Station, New York. These huge engines, which started operation in 1904, drove 5,000-kw. (maximum rating 7,500) rotating-field generators at 75 r.p.m. For central-station work they represented the end of an era of larger and larger reciprocating engines. Central-station loads had begun to grow by leaps and land values were high. Thus the necessity for concentration of generating capacity in larger units became imperative, and attention turned to the turbine.

While the immediate cause of the general adoption of turbines in central stations was the fact that reciprocating units reached the practical limit of size at a moment when turbines were there ready to step in with less first cost, much less space and, incidentally, somewhat better efficiency, this situation would never have arisen had it not been for the enormous growth of central stations. This growth, in turn, was the direct result of intensive sales methods applied to the sale of electricity.

In isolated plants conditions were different. Turbine efficiencies were much less favorable in small sizes. Moreover, most such plants used belt or rope drive for which the turbine was not fitted. Economy of space was generally less urgent than in the central-station field. So the reciprocating engine continued to hold almost complete sway in isolated plants. The Corliss and other four-valve engines continued in favor for belt drive, while the high-speed automatic was the favorite for small direct-connected electrical units.

Boiler-room practice had made great progress since 1884. Horizontal return-tubular boilers, still widely used, had been improved. The water-tube boiler was being widely adopted. Meters and regulating devices were gradually gaining a foothold. Here and there damper regulators were used. The CO_2 indicater had just been heard of, and the venturi meter had been tried out with promising results. A quaint form of motor-operated valve was on the market. Powdered-fuel equipment was available, although the results obtained on a few trials were far from promising.

More attention was given to combustion and the testing of boilers. Mechanical stokers were frequently used in the larger stations, as was equipment for handling coal and ashes.

The End of a Remarkable Decade

Another shift, this time of ten years, brings us to 1914, a year that stands out as the starting point of the World War. It also marks the termination of one of the most spectacular decades in the whole history of power development. Alert engineers everywhere had learned that combustion was a chemical process. Boilers were set higher. The slogan "fire light and often" had become a proverb. In this period science made a mass attack on the boiler room with remarkable results. Practically all of the better plants of large and medium size had adopted stokers and forced draft. Mechanical handling of coal and ash had become an old story. Engineers everywhere were concentrating attention on boiler losses and particularly the loss due to excess air. Many of the boiler-room instruments used today were available though their forms were cruder and their use much less general.

Practically the whole of the transformation of central stations from engines to turbines took place in this decade. In 1904 turbines above 500 kw. were decidedly rare. In 1914 Gold Street (Brooklyn) installed 25,000 kw. in a single cylinder.

The sudden growth of the turbine caught the boiler makers napping, but eventually led to great changes in boiler and furnace design. Where engines were taken out to make room for much greater capacity in turbines, the old boiler rooms were extended until they became unwieldly.

Several factors have entered into the reduction of boiler-room floor space per kilowatt output. One is the higher over-all efficiency of the station; another is the practice of operating boilers at high ratings. Mere size is an important factor as capacity increases roughly as the cube of one dimension, while the floor space increases as the square. The big-boiler movement in the United States was started near the end of this decade at the Delray Station of the Detroit Edison Co.

The introduction of the unaflow engine to American engineers in 1913 is particularly significant. The small steam turbine with its continually improving economy was all set to drive the older types of reciprocating engine from the field in those isolated plants where electricity was generated. The unaflow engine with its remarkable efficiency put the turbine on the defensive in the small and medium-sized plants. Incidentally, it proved a life saver to many of the engine manufacturers who feared the extinction of their business.

Oil Engine Starts to Forge Ahead

Something should be said of the oil and gas engines. In 1904 the gas engine was going strong. Less was heard of the oil engine. By 1914 the tables had been turned and the oil engine had started to forge ahead, while the gas engine was dropping back. An important factor in this connection was the expiration of the original Diesel patents, which was followed by the appearance of a number of engines of American design and construction.

The period from 1914 to date has been marked by the general refinement of existing forms of prime movers, with relatively moderate increases in maximum size. This period, and in particular that since the war, is notable for a general re-examination of scientific fundamentals in an attempt to see exactly where we stand and where future possibilities lie. About two years ago there came to be a general appreciation among intelligent engineers that the more efficient steam-operated prime movers, the unaflow engine and the large turbine, had reached a stage of development where only a slight margin for improved efficiency remained. With this realization came an intensive study of the heat cycles and heat balance. The first step was the general adoption of bleeder heating, which jumped the efficiency limit from the Rankine to the Carnot. Further increase of cyclic efficiency could come only from extending the limits of the cycle. However, little further improvement in vacuum was possible.

The only thing left to do was to increase steam pressures and temperatures. Study of the problem showed that much higher pressures were feasible. Temperatures could be raised a little, but 750 deg. F. seemed about the limit with the available materials. Even this temperature required the use of special steels and alloys in the construction of superheaters, valves, turbine nozzle chambers and other parts of equipment exposed to the steam at its maximum temperature. New standards have been developed for high-pressure pipe joints and

fittings. New heat insulation is available for high temperatures, generally to be used as an inner layer.

According to present indications central stations operating at 500 lb. will soon be common, with gradual progress to somewhat higher pressures as experience irons out difficulties. Metallurgists are working hard on the problem of strength at high temperatures. Scientists are developing new steam tables for the upper ranges. All this is having a remarkable effect on equipment. The new conditions mean different piping, different boilers and different turbines.

Great as is the significance of the present movement toward higher pressures and temperatures, it is only a part of the story. Changes in these pieces of equipment not directly affected by high pressures have been equally important.

Increased ratings, together with the attempt to cut excess air to a minimum, resulted in furnace temperatures so high as to tax refractories severely. New mixtures were developed, as were special blocks, solid, hollow or perforated. Just now water-cooled furnace walls are forging into prominence. Fans, pumps, traps, oiling systems and electrical equipment—all are undergoing a constant refinement.

Interest Awakened in Powdered Fuel

Changed conditions following the war had much to do with the remarkably sudden interest and activity in pulverized fuel. For one thing coal was much higher than before the war. Hence a gain of five points or better in efficiency was worth more than formerly. Then coal strikes had endangered fuel supplies in districts where continuous service was an essential. The ability of a pulverized-fuel installation to burn one grade of fuel today and another tomorrow gave it a certain insurance value.

Powdered fuel has, of course, had an immense effect on furnace design. The difficulty of finding refractories that would stand up against the high furnace temperatures has led to the extensive use of protective water screens in addition to those needed to cool the ash dust.

An interesting sidelight on powdered-fuel development is furnished by the stoker. The turbine had challenged the reciprocating engine. The latter answered with the unaflow. Powdered fuel's demonstrations of higher efficiency and flexibility had an immediate reaction in improved stoker design. As a result the lead in efficiency has been cut down considerably, while the stoker manufacturers point to the saving in preparation costs and furnace volume by firing with stokers.

Air heating seems to be coming in with a rush. The evaporator, once familiar only to the marine engineer, is now common in stationary plants. Deaërators have entered the field.

Even to mention all the innovations and improvements of this decade would be impossible in the allotted space, but the following are fair samples: New meters of many types, automatic centralized combustion control, deaërators and zeolite water softeners.

The value of records is universally appreciated in the large stations and to a great extent in the smaller ones. As a result an astonishing number of indicating, recording and integrating instruments have come into use.

Among the causes contributing to these changes are: More expensive coal, increased wages and land valuations, the increasing importance of reliability and a more general appreciation of the value of scientific control in every field.

The cumulative effect of all these improvements has been a steady lowering of the fuel consumption per kilowatt-hour until today one pound of coal per kilowatt-hour is in sight.

Finally, the fact must not be overlooked that the steam plant at its best still lags considerably behind the present (and past) efficiency of the Diesel engine. In spite of its higher first cost and the necessity of burning fuels generally costing more than coal per B.t.u., the remarkable thermal efficiency of the Diesel engine is appealing more and more to engineers, particularly in plants of medium size with small heating loads.

Little has been said about the continued increase in the size of turbines. In fact this increase, after passing 25,000 kw., is of less importance than some of the other recent developments.

That salesmanship has been a determining factor in fixing the size of units is clearly shown by a comparison of the present state of the electrical industry in Great Britain and America.

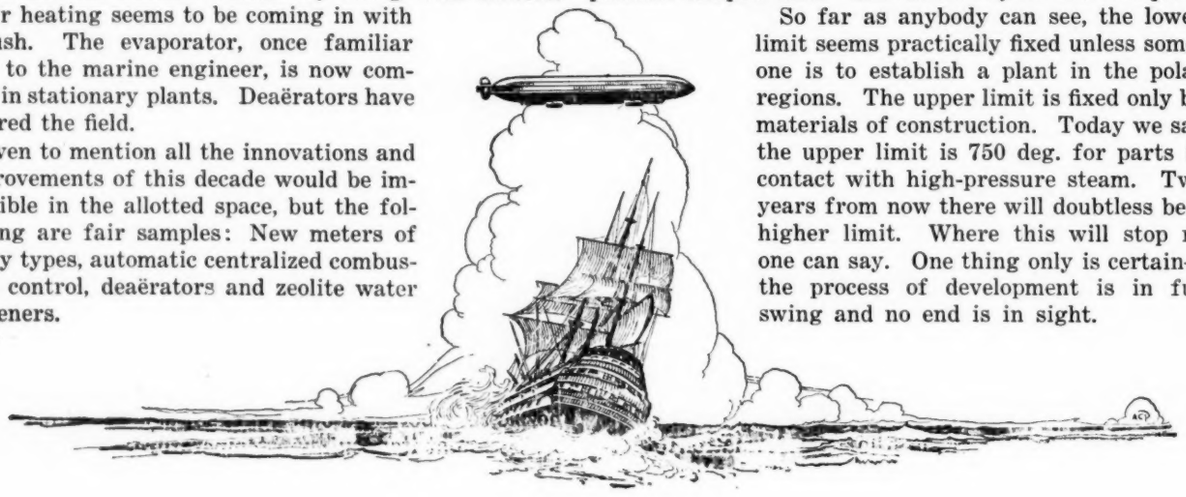
The first fact to be considered is that America consumes 500 to 800 units (kilowatt-hours per year) per capita, while the English consumption runs from 100 to 180 units. This at once makes it commercially unsound for British plants to use unit sizes that are practicable with our greater loads. The cause of this lower consumption lies in lack of salesmanship.

While power plant equipment is now in a higher state of development than ever before, it would be foolish for engineers to delude themselves with the notion that practical perfection has been reached.

It sounds good to hear of plants making a kilowatt-hour on 1.3 lb. of coal. From one point of view it has been a tremendous accomplishment. Yet, to be frank, a plant that wastes 80 per cent of all the energy in the fuel leaves something to be desired.

Sadi Carnot, whose centenary is being celebrated this year, showed that the road to greater efficiency lay in getting heat into the working medium at the highest possible temperature and rejecting heat at the lowest possible temperature. The Carnot cycle sets the pace.

So far as anybody can see, the lower limit seems practically fixed unless someone is to establish a plant in the polar regions. The upper limit is fixed only by materials of construction. Today we say the upper limit is 750 deg. for parts in contact with high-pressure steam. Two years from now there will doubtless be a higher limit. Where this will stop no one can say. One thing only is certain—the process of development is in full swing and no end is in sight.

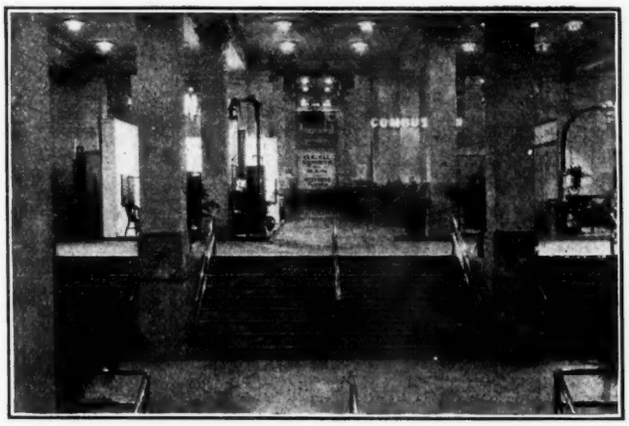


Third National Exposition of Power and Mechanical Engineering

Big Increase in Number of Exhibitors Over Last Year—Exhibits Cover Wide Range of Power Producing, Distributing and Utilizing Apparatus

THE Third National Exposition of Power and Mechanical Engineering, which is being held this week at the Grand Central Palace, New York City, surpasses in both quantity and quality of the exhibits that of the last two seasons. Last year two hundred and sixty manufacturers exhibited their products and the attendance numbered sixty-two thousand. This year the number of exhibitors has increased to three hundred and seventy and it is expected that the attendance will approach seventy-five thousand. The exposition is being held simultaneously with the annual meeting of the American Society of Mechanical Engineers and the American Society of Refrigerating Engineers, as was done last year.

A series of lectures dealing with the important developments in the various phases of power and mechanical engineering has been arranged. These lectures will be presented by authorities in the mechanical field and are scheduled to avoid conflict with the meeting of the two societies previously mentioned.



First glimpse of the power show from the main entrance of the Grand Central Palace

Working models will be much in evidence as at the previous expositions. In a large number of cases full-sized commercial units are being shown, including stokers, coal-handling equipment, pulverized-fuel systems and water-softening systems. A number of these will be amplified with drawings and photographs illustrating different types of installations.

The exhibit of boiler-room instruments is very extensive. In several cases instrument boards equipped with a complete line of indicating and recording instruments are being shown. These afford engineers the opportunity of obtaining practical information on the details and principles of their application.

In addition to its line of boiler-room instruments the Bailey Meter Co. will have on exhibit a large diagrammatic layout of a boiler equipped with a superheater, economizer, air preheater, forced and induced draft. The purpose is to show the application of air-flow, steam-flow meters, recorders and gages for proper boiler operation. It is drawn to a large scale and is colored so that the fuel, air, products of combustion, water and steam are readily disintinguished one from another. The intensity of color in each case is used to denote the temperature at different points.

Among the list of boiler-room instruments of recent development are: The Ellison-Leach CO_2 analyzer made from monel metal and Pyrex glass, exhibited by the Lewis M. Ellison Co.; Electric duplex CO_2 recorder by C. J. Tagliabue Manufacturing Co.; "Ranarex" indicating and recording CO_2 instrument by the Permutit Co.; "Apex" CO_2 indicator and recorder by Uehling Instrument Co.; Pyrometers by the Republic Flow Meters Co.; and a new line of multiple draft gages and strip-chart recorders by the American Schaeffer & Budenberg Co. Other measuring instruments of interest are the venturi meter for measuring liquid ammonia and brine in the refrigerating plant, exhibited by the Builders Iron Foundry Co., and precision type mercury-column vacuum gage, exhibited by the Taylor Instruments Companies. This gage is equipped with a vernier to read vacuums down to one-thousandth of an inch.

The manner in which valve manufacturers are solving the problem of high pressures and temperatures will be seen in a review of their exhibits, many new developments having been made during the last year. An unusually extensive exhibit is that of the Henry Vogt Machine Co., which contains 231 different valves and fittings. These constitute a complete line of drop-forged steel fittings ranging in size from 1 to 6 in. and designed for high pressures and temperatures.

A complete line of cast-steel monel-mounted valves for pressures of 400,600 and 900 lb. and temperatures up to 750 deg. F. in both hand- and motor-operated types are being exhibited by the Lunkenheimer Co. A new line of forged steel valves for high pressures and temperatures are being shown by the Edward Valve & Manufacturing Co. and the Columbus Machine Co. Recent developments in the line of non-return valves are included in the exhibits of the Elliott Co. and the Schutte & Koerting Co. A new line of steam traps having steel bodies and designed for high pressures and temperatures are being shown by the Armstrong Machine Works.

The exhibits of oil-burning equipment of both the steam and mechanical atomizing type will be found very complete. Many of these are being shown in operation, spraying water in a glass case, thus affording the opportunity of demonstrating the atomizing properties of the burners. A new type of burner in which an artificial or natural gas burner is combined with a mechanical atomizing oil burner is being shown by the Peabody Engineering Corp. This burner is

designed to facilitate changing from one fuel to the other. Also included in this line of equipment are several combined pumping and heating units.

Many developments and improvements have been made in pulverized-coal equipment during the last year. Of the six unit-type pulverizers on exhibit two are being shown for the first time. These are the Raymond (Impact) and the American (rolling-ring) pulverizers. Other exhibits of this line include types of single and multiple screw feeders, vertical and horizontal burners, pneumatic transport systems and electric pneumatic switching valves and bin signals. A section of an air-cooled furnace bottom, clinker chamber and sluiceway for pulverized coal is exhibited by the Allen-Sherman-Hoff Co., together with a section of a "catenary-curve" cast-iron coal bunker. Tight-closing ash gates for powdered-fuel furnaces and ventilated powdered-fuel hoppers are being shown by the Baker Dunbar Co. In the fuel hopper a cast-iron plate lining is used, and this in turn is protected by a hollow ventilated lining, which may be laid in horizontal or vertical courses. With the horizontal type of ventilation the air is drawn by the primary blowers across the walls of the hopper and discharged through the primary-air inlet of the burners. Where vertical ventilation is used, the air is circulated through the walls by natural draft. A new type of air preheater is being shown for the first time by Connery & Co.

Several manufacturers of refractories and furnace arches are repeating their exhibits of last year, in which sections of furnace walls and arches are shown as they would actually be set up under a boiler. Single and double suspension arches, interlocking furnace-wall construction, veneer lining for furnace walls, bonding and ledge block construction for air-cooled and ventilated walls are included in the exhibits.

The Marion Machine Foundry & Supply Co. is showing for the first time its new type AB soot blower described in *Power*, Nov. 4. The exhibit includes, also, a periscopic air indicator for oil-fired furnaces.

Motion pictures will again form a feature of the show, and as previously mentioned, a series of lectures will be presented. The lectures have been scheduled as follows:

Dec. 2, 2 p.m., "Hydraulic Equipment," by W. M. White, Hydraulic Dept., Allis-Chalmers Co.; Dec. 3, 2 p.m., "Materials Handling," by Matthew W. Potts, of *Industrial Management;* Dec. 3, 8 p.m., "Mechanical Refrigeration," by Frank L. Fairbanks, chief engineer of the Quincy Cold Storage Co.; Dec. 4, 2 p.m., "Steam Prime Movers," by C. Harold Berry, technical engineer of power plants, Detroit Edison Co.; Dec. 4, 8 p.m., "Machine Tools," by Ralph Flanders, manager Jones & Lamson Machine Co.; Dec. 5, 2 p.m., "Mechanical Power Transmission," by G. A. Ungar, Engineering and Commerce Corp.; Dec. 5, 8 p.m., "Oil and Gas Engines," by Dr. Charles E. Lucke, professor of mechanical engineering, Columbia University.

In the foregoing, brief mention is made of some of the new and improved devices that are being exhibited, this mention having been made possible through information furnished in advance by the manufacturers. A more complete description involving additional equipment will be contained in the report of the Power Show which is to appear in the Dec. 9 issue. A list of the manufacturers and their products follows:

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS

Booth No.	Manufacturer	Product
539	Ackerman-Johnson Co., Chicago	.....
260	Advance Engineering Co., New York	"Armstrong" cast-iron and cast-steel steam traps
319-320	Aero Pulverizer Co., New York	Coal pulverizing and burning equipment
204	Alberger Heater Co., Buffalo	Heaters, oil coolers and evaporators
429	Alexander Bros., Philadelphia	Belting
75	Allen-Sherman-Hoff Co., Philadelphia	"A-S-H" air-cooled furnace bottoms, ash hoppers, gates and sluiceways
212	Alsop Engineering Co., New York	Laboratory equipment
58	American Arch Co., Inc., New York	Suspended furnace arches
495	American Blower Co., Detroit	"Sirocco" fans, blowers, air-conditioning equipment
65	American Brass Co., New York	Condenser tubes, brass pipe and rods
525	American Car & Foundry Co., New York	"Berwick" electric rivet and metal heaters, "Halyburton" valves
208	Armstrong Cork & Insulation Co., Pittsburgh	Cork heat insulation, cork isolating blocks for machinery foundations
432	American Pulverizer Co., St. Louis, Mo	Coal pulverizing and burning equipment, coal crushers and firebrick pulverizers
74	American Schaeffer & Budenberg Corp., Brooklyn	Indicating and recording gages and thermometers, tachometers, valves and fittings, steam pecialties.
412	Ames B. C. Co., Waltham, Mass.	Bench lathes, milling and filing machines, dial gages
65	Anaconda Copper Mining Co., New York	Anaconda products, condenser tubes, brass and copper pipe, rods
95A	Andale Engineering Co., Philadelphia	Duplex strainers for water and oil
17	Andrews-Bradshaw Co., Pittsburgh	"Tracy" steam purifier
213-214	Area Regulators, Inc., New York	"Area" automatic regulators
260	Armstrong Machine Works, Three Rivers, Mich	High- and low-pressure steam traps
60	Ashcroft Manufacturing Co., New York	Valves, gages, steam specialties
38	Ashton Valve Co., New York	Indicating and recording gages, master pilot gages, safety valves, oil-relief valves
80	A.S.M.E.	.....
80	A.S.H. & V.E.	.....
552-553	Attwood & Morrill, New York	Atmospheric relief valves
90	Babbitt Steam Spec. Co., New Bedford, Mass	Adjustable sprocket rims and specialties
54-55	Bailey Meter Co., Cleveland	"Bailey" air-flow, steam-flow meters; pressure and temperature recorders, indicating and recording tachometers, multi-point gages.
16	Baker Dunbar Co., Cleveland	Ventilated pulverized-coal hoppers, ash hoppers, hand- and power-operated ash gates
249	Ballwood Co., The, New York	Pipe, bends and coils
547	Barco Manufacturing Co., Chicago	Lubricated plug valves, flexible joints
313	Barnes & Jones, Boston	Modulation and thermostatic valves, condensators and traps for heating systems
427-428	Bartlett Hayward Co., The Baltimore	"Fast's" flexible coupling
312	Bassick Manufacturing Co., Chicago	Lubricators
550	Bayer Co., The., St. Louis	Soot blowers
50-51	Beaumont Co., R. H., Philadelphia	Coal- and ash-handling systems, skip hoist with simplex loader, suspended steel bunker, weigh larry and cable drag scraper
50-51	Beaumont Manufacturing Co., Philadelphia, Pa	.....
78	Bernitz Furnace Appliance Co., Boston	Clinker-proof furnace walls and blocks
70-71	Bethlehem Shipbuilding Corp., Ltd., Bethlehem, Pa	"Bethlehem-Dahl" oil-burning systems, turbo and reciprocating feed pumps
70-71	Bethlehem Steel Co., Bethlehem, Pa	Diesel engines
68	Bigelow Co., The, New Haven, Conn	Water-tube boilers
413	Blast furnace & Steel Plant, Boston	.....
437	Blackburn Smith Corp., New York	Feedwater filter and grease extractors
558	Blacker Engineering Co., New York	"Mechanical helper" blacksmith hammers

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS—Continued

Booth No.	Manufacturer	Product
10	Boig & Hill, Inc., New York	Cut gears and transmission chains
550	Boiler & Equipment Supply Corp., New York	"Bayer" soot blowers
340-341-342	Boston Gear Works, Norfolk Downs, Mass.	Gears, sprockets, chains and universal joints
247	Bradley Washfountain Co., Milwaukee	Wash fountains
423	Brady Conveyors Corp., Chicago	Steam-jet ash conveyors, flat suspended furnace arches
44-A	Bridgeport Brass Co., Bridgeport, Conn	Condenser tubes, brass tubing, rods, sheets, wire, etc.
12	Bristol Co., The, Waterbury, Conn	Recording pressure and vacuum gages, electric temperature controls, indicating and recording thermometers and pyrometers
28	Brown Engineering Co., Reading, Pa	Kantilever spring coupling "Jackson" time saving vise, "Brown" stock rack
323	Brown Instrument Co., Philadelphia	Electrical CO_2 recorders, pyrometers, recording instruments
290	Budd Grate Co., Philadelphia	Furnace grates
73	Buffalo Forge Co., Buffalo	Fans, blowers, exhausters, air-coolers, purifiers and preheaters
73	Buffalo Steam Pump Co., Buffalo	Duplex and centrifugal pumps
276	Builders Iron Foundry, Providence, R. I.	Venturi indicating and recording meters for steam, water, liquid ammonia and brine
8	Bundy Steam Trap Co., Nashua, N. H.	Steam traps
A	Burhorn Co., Edwin, New York	Cooling towers
263	Cambridge & Paul Inst. Co. of America, Ossining-on-Hudson, N. Y.	Electric CO_2 indicators and recorders, "Collins" micro-indicators for internal-combustion engines
410	Campbell, Andrew C., Inc., Bridgeport, Conn.	Nibbling machines
22	Carborundum Co., The, Perth Amboy, N. J.	Refractories
566	Carey Co., The Philip, Cincinnati	Pipe-covering and heat-insulating materials
17	Carling Turbine Blower Co., Worcester, Mass.	Turbo- and motor-driven blowers, small steam turbines
285	Carr Fastener Co., Cambridge, Mass.	"Dot" lubricators and fasteners
423	Carrick Engineering Co., Chicago	Automatic boiler-control equipment
73	Carrier Air Conditioning Co. of America, Buffalo	Air-conditioning equipment
28	Cash Co., A. W., Decatur, Ill.	Pressure reducing and regulating valves, fan engine regulators, expansion and relief valves
14	Celite Products Co., Chicago	"Sil-O-Cel" insulating bricks and blocks, "Celcote" boiler coating, "Fraxite" high temperature cements
441	Central Forging Co., Catawissa, Pa.	Forged fittings
543	Centrifix Corp., Cleveland	Steam purifier
2	Chapman Valve Mfg. Co., Indian Orchard, Mass.	Valves for high and low pressures, motor-operated gate valves
440	Chatillon & Sons, John, New York	Industrial scales and specialties
343	Clark Electric Co., Jas. Jr., Louisville, Ky.	Motor-driven drills and grinders
92	Cleveland Worm Gear Co., Cleveland	Worm-gear speed reduction units
300 to 305	Climax Engineering Co., Clinton, Iowa	Gasoline, kerosene and natural-gas engines, refrigerating machines
337	Clipper Belt Lacer Co., Grand Rapids, Mich.	Steel belt lacing
67	Cochrane Corp, Philadelphia	Flowmeters for steam, air and water. V-notch meters and recorders, pressure filters, heaters, water softeners, multiport back-pressure valves
15-B	Coen Company, New York	Mechanical and steam atomizing oil burners, oil heaters, duplex oil strainers
509	Columbus Machine Co., New York	Forged steel valves
23	Combustion Engineering Corp., New York	Mechanical stokers, pulverized-coal and oil-burning equipment
53	Combustion Pub. Corp., New York	.....
92	Connelly Boiler Co., D., Cleveland	Bent-tube and sectional header cross-drum type boilers
329	Conner, Inc., Wm. B., New York	Steam specialties
43	Connery & Co., Inc., Philadelphia, Pa.	Steel plate work, expansion stiffeners for breechings, air ducts, etc.; preheaters
60	Consolidated Safety Valve Co., New York	Safety valves and fittings
328	Continental Valve & Equipment Co., Framingham, Mass.	Forged fittings and reducing valves
32	Coppus Engineering Corp., Worcester, Mass.	Steam-turbine and motor-driven blowers, centrifugal turbo boiler-feed pumps
241-242	Cory & Son, Inc., Chas., New York	Motor operated gate valves, flow indicators for steam, air and water
52	Crane Co., Chicago	Valves, fittings and specialties
261	Crane Packing Co., Chicago	Flexible metallic packing, metallic condenser-tube packing
277-278	Crosby Steam Gage & Valve Co., Boston	Indicating and recording gages; safety, blowoff and relief valves
286	Culm-Burn Equipment Co., Philadelphia	Water-cooled grates for burning small-sized anthracite
248	Dampney Co. of America, Boston	Protective coating for meta surfaces
36-37	Davidson Co., M.T., New York	Steam pumps
10	D'Este Co., Julian, Boston	"Curtis" damper regulators, reducing valves traps and temperature regulators
13	Dearborn Chemical Co., Chicago	Feed-water treatment "No Oxid," rust preventative, lubricating oils and greases
526-527	De Laval Separator Co., New York	Oil purifiers
94	Detrick Co., M. H., Chicago	Suspended furnace arches
222	Detroit Belt Lacer Co., Detroit	Metal belt lacing
206-207	Detroit Stoker Co., Detroit	Multiple-retort underfeed stoker
512	Diamond Chain & Mfg. Co., Indianapolis	Transmission chains
17	Diamond Power Specialty Co., Detroit	Soot blowers
486	Dick Co., Inc., R. & J., New York	Belting, shafting and steel pulleys
423	Dickson & Co., Walter S., New York	Pressure regulating valves, steam traps and specialties
508	Dixon Crucible Co., Jos., Jersey City	Boiler graphite, lubricants
208-A	Dodd, Mead & Co., New York	.....
27	Dodge Corp., F. W., New York	Sweet's Engineering Catalog
41	Drake Non-Clinkering Furnace Block Co., New York	Non-clinkering furnace blocks, furnace door safety latch
488	Durable Mfg. Co., New York	Packing, paints, valve disks
12-A	Eastern Steam Specialty Co., New York	Steam traps and pumps
288-289	Edge Moor Iron Co., Edge Moor, Del.	Water-tube boilers, waste-heat systems
30	Edward Valve & Mfg. Co., East Chicago	High-pressure forged steel valves, motor-operated valves, fittings and specialties
271-272-273	Elliott Co., Jeannette, Pa.	Steam and oil separators, strainers, blowoff valves, test kit for measuring corrosiveness of water
44-B	Ellison, Lewis M., Chicago	"Ellison-Leach" CO_2 analyzer, inclined and vertical draft gages
28-A	Engineers Book Shop, New York	.....
18	Engineer Co., The, New York	"Turner" baffle walls, "Enco" oil burners, balanced draft furnace pressure regulators
217-218	Erie City Iron Works, Erie, Pa.	Pulverized-coal apparatus, "Lentz" engines, water-tube boilers
76	Ernst & Co., Newark, N. J.	Inclined boiler gages, fillings
100-101	Everlasting Valve Co., Jersey City, N. J.	"Everlasting" blowoff valves
246	Fafnir Bearing Co., New Britain, Conn.	Industrial ball bearings
531	Fairbanks Co., New York	Valves and steam specialties
330-331	Fairbanks, Morse & Co., Chicago	Steam and motor-driven pumps, centrifugal pumps, air compressors—electric motors
17	Falls Engine Stop Co., Sheboygan, Wisc.	Automatic engine stops
338-339	Falk Corporation, Milwaukee	Herringbone gearing, conveyor drives, flexible couplings
425-426	Farnsworth Co., Norristown, Pa.	Steam traps
438	Federal Gauge Co., Chicago	Gages, steam specialties
226	Filtration Engineers Inc., New York	Self-priming centrifugal pumps, "La Bour" vacuum heating return systems
564	Filtrators Co., The New York	Feed-water treating systems
15-A	Fisher Governor Co., Marshalltown, Iowa	Pump governors, reducing valves, pressure regulators, steam traps, liquid level controllers
315	Flexible Steel Lacing Co., Chicago	"Alligator" steel belt lacing, "Flexco" belt fasteners and lamp guards
46	Flynn & Emrich Co., Baltimore, Md.	"Huber" hand stoker, mechanical stokers
540	Foote Bros. Gear & Mch. Co., Chicago	Speed-reduction units
84	Foster Engineering Co., Newark, N. J.	Pressure regulators, non-return valves, pump governors
62	Foxboro Co., The, Foxboro, Mass.	Indicating and recording gages and thermometers, CO_2 recorders
92	Frederick Iron & Steel Co., Frederick, Md.	"Spirex" vacuum pumps

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS—Continued

Booth No.	Manufacturer	Product
14-A & 14-B	Fuller-Lehigh Co., Fullerton, Pa.	"Fuller-Lehigh" coal pulverizing, transporting and burning equipment, waste-heat coal driers.
252-253	Fulton Co., The, Knoxville, Tenn...	Temperature regulators and valves
41	Furnace Engineering Co., New York	"Simplex" unit-type coal pulverizer
542	Garlock Packing Co., Palmyra, N. Y.	Asbestos, rubber, metal and fibrous packings "Veritemp" metal ammonia packing
546	Garratt Callahan Co., New York	"Magic" boiler preservative
4-5	General Electric Co., Schenectady, N. Y.	Small steam turbines, surface air coolers, electric steam generator, flow meters, industrial control devices, "Fabroil" gears
274-275	Gifford Wood Co., Hudson, N. Y.	Coal-handling equipment and ice machines
87-88	Gillis & Geoghegan, Inc., New York	Telescopic hoists for ash removal
262	Girtanner Engineering Corp., New York	Steam ash conveyors and hand stokers
565	Globe & Kneadable Metallic Packing Co., Brooklyn	Metallic packing
414	Goodman Manufacturing Co., Chicago	Industrial hoisting machinery
92	Gordon Co., James T., New York	Strainers, valves, vacuum pumps, worm gear drives
35	Graver Corp., East Chicago, Ind.	Water softening and treating apparatus
201-202-203	Green Fire Brick Co., A. P., Mexico, Mo.	Firebrick and refractories
49	Griscom-Russell Co., New York	U-fin generator air coolers, air ejectors, evaporators, heaters, oil coolers
21	Hagan Corp., Pittsburgh	Automatic boiler-control systems, deconcentrators, concentration gages, steam purifiers and heaters
60	Hancock Inspirator Co., New York	Gages, valves, steam specialties
46	Hand Stoker, The, New York	"Huber" hand stoker, hopper-feed hand stoker
557	Hanson Tap & Gauge Co., Hartford, Conn.	Taps, dies, gages, small tools
557	Hanson-Whitney Mch. Co., Hartford, Conn.	Drill presses and milling machines
60	Hayden & Derby Mfg. Co., New York	"Metropolitan" injectors, valves and gages
81	Hays Corp., Jos. W., Michigan City, Ind.	CO_2 recorders and draft gages
88	Hill Clutch Mch. & Fdry. Co., Cleveland	Collar oiling bearings, friction clutches, rope drives, hangers, etc.
502	Hofft, M. A., Co., Indianapolis, Ind.	"National" boiler arches
544	Hollow Ball Co., Baltimore	Aluminum, bronze and steel balls
204	Howard Iron Works, Buffalo	Feed-water heaters and expansion joints
230	Howden & Co., Jas., of America Inc., New York	Air preheaters
81	Huyette Co., Paul B. Philadelphia	"Hays" CO_2 and draft recorders, draft gages and gas analyzers "P.B.H." water gage, damper regulators
10	H & O Chain Co., South Norwalk, Conn.	Transmission chains
441	Hydraulic Press Mfg. Co., Mt. Gilliad, Ohio	Forged steel fittings
423	Illinois Engineering Co., Chicago	Pressure-regulating valves, steam traps
314	Industrial Management Group, New York	
39	Industrial Power, Chicago	
551	Insulating Products Corp., New York	Insulating materials
23-24-25	International Combustion Engr. Corp., New York	Underfeed, overfeed and traveling-grate stokers; "Lopulco" pulverized-coal equipment, air preheaters and oil-burning equipment
283-284	International Correspondence Schools, Scranton, Pa.	
506	International Filter Co., Chicago	Water filters and purifiers
9	International Nickel Co., New York	Samples of commercial uses for monel metal for power-plant equipment
485	Irving Iron Works Co., Long Island City, N. Y.	"Irving" subway grating, floors, stair-treads
90	Jenkins Bros., New York	Valves, brass, iron, bronze, semi-steel and cast steel; pump valves, sheet packings
93	Jointless Fire Brick Co., Chicago	"Plibrico" refractories
510-511	Jones Foundry & Mch. Co., Chicago	Speed-reduction units, flexible coupling, shaft hangers, etc.
412	Jones & Lampson Corp., Springfield, Vt.	Turret lathes
211	Keeler Co., E., Williamsport, Pa.	Water-tube boilers
72	Kellogg Co., M. W., New York	Pipe, valves and fittings
271	Kerr Turbine Co., Wellsville, N. Y.	Steam turbines, reduction gears
296-297	Key Boiler Equipment Co., East St. Louis, Ill.	"Key" safety handhole caps and plates
8-A	Keystone Lubricating Co., Philadelphia	"Keystone" safety lubricating systems lubricants, grease
11	Keystone Refractories Co., New York	"Dura-stix" bonding mortar
95	King Refractories Co., Inc., Buffalo	"Mono" boiler baffles and furnace cements
19	Kissick Fenno Co., New York	Soot cleaners and feed-water regulators
317	"Klingerit," Inc., New York	Valves, packings, gage glasses
530	Korfund Co., Inc., New York	"Korfund" cork plates for isolating machinery foundations
225	La Bour Co., Chicago Heights, Ill.	Self-priming centrifugal pumps
91	Ladd Co., George T., Pittsburgh	Water-tube boilers
271	Lagonda Manufacturing Co., Springfield, O.	Non-return valves, tube cleaners and specialties
86	Lead Lined Iron Pipe Co., Wakefield, Mass.	Lead-lined pipe and fittings
272	Liberty Manufacturing Co., Pittsburgh	Boiler-tube cleaners
203	Liptak Fire Brick Arch Co., Chicago	"Liptak" single and double suspension arches interlocking furnace walls, bonding and ledge block construction for air-cooled walls
307	Locke Regulator Co., Salem, Mass.	Damper regulators, reducing valves, stop and check valves, engine stop and speed-limit systems
63	Lunkenheimer Co., The, Cincinnati	Cast-steel, monel mounted gate globe, check, non-return and blowoff valves; motor-operated valves, boiler mountings
24	Lopulco Co., New York	"Lopulco" pulverized-coal feeders and burners
411	McCroskey Tool Co., Meadville, Pa.	Chucks, drills, reamers, general tools
13	McLeod & Henry Co., Troy, N. Y.	Flat suspended boiler arches, "steel-mixture" veneer lining for furnace walls
321	McVicker Co., W. M., Brooklyn	Boiler compound
226	M & M Engineering Co., New York	Self-priming centrifugal pumps
431	Machine Tool Historical Exhibition	
34	Mack Engineering & Supply Co., New York	Refractories
541	Management & Administration, New York	
60	Manning Maxwell & Moore, Inc., New York	Gages, "Consolidated" safety valves, "Reeves" variable speed transmission
40	Manufacturers Record, Baltimore	
280	Maphite Sales Corp., St. Louis	Furnace-wall coating
209-210	Marion Mch. Fdy. & Supply Co., Marion, Ind.	Soot blowers, periscopic air indicator, hand stokers
216	Marlin Rockwell Corp., Jamestown, N. Y.	"Gurney" ball bearings
258	Mason Regulator Co., Boston	Reducing valves, pump, pressure and damper regulators
424	Mason Volney Co., W., Providence, R. I.	Pulleys, clutches, hoists
267	Merco-Nordstrom Valve Co., San Francisco	Lubricated plug valves
237-238-239	Merrick Scale Mfg. Co., Passaic, N. J.	Scales and weigh larries
32	Merritt & Co., L. R., New York	Boilers, engines and blowers
12-A	Metallo Gasket Co., New York	Gaskets for steam, air, water and chemical services; monel metal and steel gaskets for high pressures
322	Midwest Air Filters, Inc., New York	Air filters and humidifiers
268	Midwest Piping & Supply Co., St. Louis	Pipe and fittings
322	Midwest Steel & Supply Co., Inc., New York	Air filters, compressors, bulldog timber-joint plates
411	Modern Machine Tool Co., Jackson, Mich.	Machine Tools
265	Morse Chain Co., Ithaca, N. Y.	Silent-chain drives
344-345	Morse Dry Dock & Repair Co., Brooklyn	Fuel-oil burners
254	Moto Meter Co., Inc., Long Island City, N. Y.	"Motoco" industrial thermometers
501	Mueller Co., Inc., Decatur, Ill.	Valves and fittings
500	Mueller Metals Co., Port Huron, Mich.	
66	Nash Engineering Co., South Norwalk, Conn.	Compressors and pumps, return-line systems
82	N. A. S. E.	
528	N. K. A. Ball & Disc Bearing Co.	Ball and disk bearings
76	National Co., Boston	Water-column illuminators
82	National Engineer, Chicago	
433-431	National Museum of Engineering	
81	National Regulator Co., Chicago	Regulators and specialties
8-B	National Tube Co., Pittsburgh	Pipe
93	Neemes Foundry, Inc., Troy, N. Y.	Furnace grates
346-347	New Departure Mfg. Co., Bristol, Conn.	Ball bearings

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS—Continued

Booth No.	Manufacturer	Product
341	Nicetown Ball Bearing Co., Nicetown, Pa.	Ball bearings
95-A	Nicholson & Co., W. H., Wilkesbarre, Pa.	Steam traps, three- and four-way controlling valves, steam specialties
484	Niles-Bement-Pond Co., New York	Machine tools
549	Nitrose Co., The, Peoria, Ill.	Protective paints for metal surfaces
234-235	Norma Co. of America, Long Island City, N. Y.	"Norma" ball bearings and "Hoffman" roller and ball bearings
19	Northern Equipment Co., Erie, Pa.	"Copes" feed-water regulators and pump governors
324-325	Norton Co., Worcester, Mass.	Refractories
227	Olsen, Tinius Testing Mch. Co., Philadelphia.	Hardness testers static dynamic balancing machine, static weighing scales
228	Orange Bearing Co., Orange, N. J.	Bearings
57	Otis Elevator Co., New York.	Heavy-duty motor controllers model of passenger escalators
16	Payne Dean, Ltd., New York.	Motor-operated valve control systems, station load indicators, turbine signal systems
47	Peabody Engineering Co., New York	"Peabody" fuel-oil burning equipment
287	Pennsylvania Crusher Co., Philadelphia.	Coal crushers and conveyors
262	Perfection Grate & Supply Co., Springfield, Mass.	Hand stokers
556	Perolin Co. of America, Chicago	Boiler-water treatment
13	Permutit Co., New York.	Water softening and filtering equipment "Ranarese" indicating and recording CO_2 instrument
10	Philadelphia Gear Works, Philadelphia	Cut gears
91	Pittsburgh Testing Laboratory, Pittsburgh	Laboratory equipment
4	Pittsburgh Valve Fdry. & Construction. Co., Pittsburgh	Motor and cylinder operated gate valves, steam separators and fittings
343	Porter-Richards Mchy. Co., Philadelphia.	Industrial locomotive
504	Powell Co., Wm., Cincinnati.	Valves, fittings and specialties
42	Power, New York	
98	Power Plant Engineering, Chicago	
20	Power Specialty Co., New York	"Foster" superheaters, economizers, water-walls and water-backs
505	Power Transmission Co., New York	Ball-bearing equipment
483-484	Pratt & Whitney Co., New York	Machine tools
219-220	Preferred Utilities Co., Inc., New York	Oil-burning equipment
306	Pyramid Iron Products Corp., New York	"Pyramid" grates
420	Puller Mfg. Co., New York.	
496	Queen's Run Refractories Co., Inc., Lock Haven, Pa.	Firebrick and refractories
89	Quigley Furnace Specialties Co., New York	"Hytempite" refractory material, high temperature insulation
3	Racine Tool & Mch. Co., Racine, Wis.	Machine tools
292-293	Ramsey Chain Co., Albany, N. Y.	Silent-chain drives
219	Ray Manufacturing Co., W. S., San Francisco, Cal.	Fuel-oil burning equipment
25	Raymond Bros. Impact Pulv. Co., Chicago, Ill.	Coal-pulverizing equipment
48	Reading Steel Casting Co., Bridgeport, Conn.	Valves, fittings and specialties,
316	Reed Air Filter Co., Inc., Louisville, Ky.	Air filters
81	Reliance Gauge Column Co., Cleveland.	"Reliance" forged steel water columns
548	Ren Manufacturing Co., Winchester, Mass.	Lamp locks and electrical specialties
6	Republic Flow Meters Co., Chicago	Meters for steam, air and gas; draft indicators and recorders, pyrometers illuminated-dial load indicators, coal meters
291	Research Engineering Corp., New York	Motor-operated valves
240	Richardson Scale Co., Passaic, N. J.	Automatic scales and weigh larries
79	Riley Stoker Co., Sanford, Worcester, Mass.	"Riley" underfeed stoker, lateral retort stoker
536	Roberts Steam Specialty Co., Cleveland	Water-columns, boiler mountings, steam specialties
215	Robinson John R., New York.	Gaskets
411	Rockford Machine Tool Co., Rockford, Ill.	Machine tools and specialties
11-A	Roto Co., The, Hartford, Conn.	Boiler-tube cleaners
332-333	S.K.F. Industries, Inc., New York.	"S.K.F." ball bearings, shaft hangers and pillow blocks
318	"S-C" Regulator Mfg. Co., Fostoria, Ohio.	Feed-water regulators, pump governors, drainage controls
535	Safety Equipment Service Co., Cleveland.	Goggles and helmets, general safety equipment
336	Sandvik Steel, Inc., New York.	Steel belt conveyors
33	Sarco Company, Inc., New York.	Steam traps, radiator traps, temperature regulators
534-535	Schutte & Koerting Co., Philadelphia.	Valves, evaporators, heaters, spray nozzles, condensing and oil-burning equipment
69	Scovill Manufacturing Co., Waterbury, Conn.	Admiralty condenser tubes, brass sheet, rod, wire and seamless tubing
255	Seminole Chemical Co., Inc., New York.	Method of cleaning boilers
26	Sharples Specialty Co., Philadelphia.	"Sharples" portable-centrifugal oil purifier
76	Simplex Valve & Meter Co., Philadelphia.	Indicating and recording boiler-feed meters, indicating manometer
76	Skeen & Co., D. H., Chicago.	
554-555	Skinner Bros. Mfg. Co., Inc., Elizabeth, N. J.	Heating and ventilating apparatus
281-282	Smidth & Co., F. L., New York	"Lenix" belt drives
17	Smith Gas Engineering Co., Dayton, Ohio.	Gas producers
85	Smith & Serrell, Newark, N. J.	"Francke" flexible couplings, "Pintite" rigid couplings, "Keytite" self-fitting keys
10	Southern Engineer, Atlanta, Ga.	
76	Sowdon, W. K., New York.	Gages, high and low safety water columns, inclined water-gage columns, water-column illuminators
28	Spence Co., Paulsen, New York	"Kantilever" spring couplings, reducing and regulating valves, draft regulators sterling boiler feed systems, steam traps
31	Springfield Boiler Co., Springfield	Water-tube boilers
245	Standard Steel & Bearings, Inc., Plainville, Conn.	Ball bearings
28	Standard Water Systems Co., Hampton, N. J.	Evaporators and heaters
28	Sterling Engr. & Equipment Corp., Hyde Park, Mass.	"Sterling" boiler feed systems, lifting and separating traps
26	Stewart-Sayers Co., New York.	"Northwestern" boiler-damper controls, natural draft controls, "Benz" compressorless diesel engine
503	Stroh Steel Hardening Process Co., Pittsburgh.	
532	Strom Ball Bearing Mfg. Co., Chicago.	Ball bearings
56	Superheater Co., The, New York	"Elesco" superheaters
229	Swartwout Co., The, Cleveland	Steam and oil separators and traps, exhaust heads, feed water heaters, return traps
27	Sweet's Engineering Catalog, New York.	Engineering catalogs
59	Tagliabue Mfg. Co., C. J., Brooklyn, N. Y.	Indicating and recording thermometers, "Mono" CO_2 instruments, fuel-oil shut-off valves, temperature and pressure controllers, oil testing instruments and hydrometers
538	Talcott, Inc., W. O. & M. W., Providence, R. I.	Tools, supplies and accessories
507	Taylor Instrument Co.'s, Rochester, N. Y.	Indicating and recording thermometers, pyrometers, mercury column-vacuum and pressure gages, barometers
98	Technical Publ. Co.	
256-257	Techno Service Corp., New York	"Borsig" valves, sludge pump for power plants
264	Temperature Control Co., Baltimore.	Temperature-control apparatus
28	Templeton Mfg. Co., Hyde Park, Mass.	Steam traps
222	Thomas Flexible Coupling Co., Warren, Pa.	Flexible shaft couplings
560	Thompson & Son Co., Henry G., New Haven, Conn.	Metal cutting machinery and tools
95-A	Tide Water Oil Sales Corp., New York.	Oils and greases
499	Toledo Pipe Threading Mch. Co., Toledo, Ohio.	Pipe cutting and threading machines, hand stocks and dies
498	Toledo Scale Co., Toledo, Ohio.	Industrial weighing equipment
497	Topping Bros., New York.	Tools, supplies and accessories
497	Torchweld Equipment Co., Chicago.	Welding apparatus
505	Transmission Ball Bearing Co., Buffalo.	Ball bearings
412	Triplex Machine Tool Co., New York.	Turning and boring; milling, drilling and cutting machines
45	Uehling Instrument Co., Paterson, N. J.	CO and CO_2 recorders, combined barometer and vacuum recorders, pyros-porous gas filter
439	Universal Coal Spreader Co., Chicago.	"Universal" coal spreader for stoker hoppers
442-443	Universal Fixture Corp., New York.	Display and tool racks
533	Vacuum Oil Co., New York.	Lubricating oils and greases

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS (Concluded)

Booth No.	Manufacturer	Product
244	Vasil Steam Systems Co., Washington, D. C.	Steam traps for heating systems
17	Vincent-Gilson Engr. Co., New York	Soot cleaners and turbine blowers
268-269-270	Vogt Machine Co., Henry, Louisville, Ky.	"Vogt" drop-forged steel valves and fittings
279	J. H. H. Voss, New York	
19	Vulcan Soot Cleaner Co., Du Bois, Pa.	Soot cleaners
221	Wailes Dove-Hermiston Corp., New York	Paints and enamels for metal surfaces
266	Waite & Davey Co., Long Island City, N. Y.	Air-cooled flat suspended furnace arches and furnace blocks
250-251	Walsh & Weidner Boiler Co., Chattanooga, Tenn.	Water-tube boilers
308 to 311	Walworth Manufacturing Co., Boston	Globe and gate valves, fittings and specialties
231	Warren Steam Pump Co., Warren, Mass.	Vertical and horizontal duplex pumps, centrifugal boiler-feed pumps
223-224	Webster & Co., Warren, Camden, N. J.	Modulation system of steam heating, feedwater heaters, packless valves, boiler return and vent traps
309	Watts Regulator Co., Lawrence, Mass.	Feed-water regulators, damper and pressure regulators, pump governors
99	Wayne Tank & Pump Co., Fort Wayne, Ind.	Oil-handling, storage and dispensing apparatus; water-softening equipment
529	Westco-Chippewa Pump Co., Davenport, Iowa	Deep-well plunger pumps, high-pressure single-stage pumps
77	Wheeler Manufacturing Co., C. H., Philadelphia	Condenser, radojet air pump, dry vacuum pumps, dynamotor for testing horsepower of prime mover
64	Wheeler Condenser & Engr. Co., Carteret, N. J.	Condensers, evaporators, cooling towers, steam-jet air pumps, hotwell pumps
557	Whitney Manufacturing Co., Hartford, Conn.	Silent and roller type chain drives, keys and cutters, hand milling machines
76	Williams Gauge Co., Pittsburgh	"Stets" boiler-feed controllers, gages, high and low-water alarm columns
416-417	Wilson Welder & Metals Co., Inc., Hoboken, N. J.	Electric-welding apparatus
61	Wing Manufacturing Co., L. J., New York	Turbo- and motor-driven blowers, unit heaters and exhausters
286	Wolff & Munier, Inc., New York	Water-cooled grates for burning small-sized anthracite
528	Wollmar Engineering Corp., New York	Ball and disk bearings
236	Wright-Austin Co., Detroit	Steam and oil separators, steam and air traps, strainers, low-water alarms, steam specialties
259	"X" Laboratories, New York	"X" Liquid for repairing leaks in boilers and hot-water systems
493-494	Yale & Towne Mfg. Co., New York	Geared and differential blocks, electric chain hoists, industrial trucks
7-A & 7-B	Yarnall Waring Co., Philadelphia	Motor-operated blowoff valves, V-notch meters, spray heads, steam traps, unloaders

Preheating Fuel Oil for Diesel Engines

BY ROBERT A. MELROSE

Fuel oils with an asphaltum base or having a low Baumé reading become viscous at low temperatures and often give trouble due to their tendency to solidify with consequent choking of the fuel pump and pipes. This condition makes itself manifest first in installations where the service tank is below the fuel pump level, as the congealing naturally adversely interferes with the suction efficiency of the fuel pump.

To counteract this difficulty several preheating systems have been devised in order to insure that the oil will at all times flow freely and keep the fuel pump flooded—such as steam, electricity and exhaust gases from the engine itself. Each system depends to a great extent on the conditions prevailing at the particular location in question for its ultimate economy, and it is sometimes advisable to install a combination of two of the designs mentioned; particularly is this the case when dealing with tar oil.

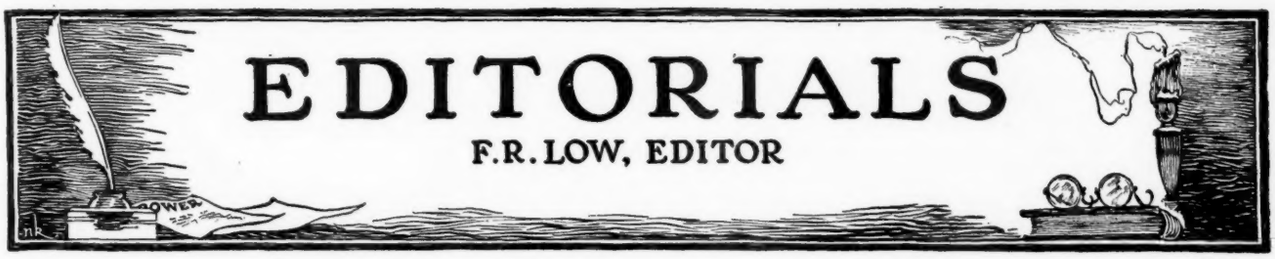
Steam coils have been largely used with success, and furthermore, steam is easy to control and is usually at hand, as it is a practical certainty that there is a heating boiler in the plant. It is preferable that the heating coil be continuous, but this construction, although easily accomplished where the service tank is concerned, presents a problem when we take the storage tank into consideration, due to the fact that this tank is generally built on a generous scale. The reason for suggesting a continuous coil is, that, with the perversity of all things that are intended to remain tight, joints have a tendency to blow out at the most inopportune moments.

Where a waste-heat boiler is installed for heating purposes steam is an economical medium, but when starting from cold it would be necessary, assuming that there are no other engines running, either to have a connection from a heating boiler or start the engine on light oil and run until steam was raised on the waste-heat boiler. This method introduces some complications, as a diversity in the specific gravity, or Baumé reading, would alter combustion conditions considerably, inasmuch as a fuel valve set to handle tar oil would in all probability produce constant volume conditions with a light oil and consequent high increase of initial pressure.

Electricity is rather a doubtful medium for fuel-heating purposes for the simple reason that a bare coil system may be designed not to exceed a certain temperature when new, but after having been in operation for some time, owing to decrease of the cross-sectional area of the wire, the resistance increases, with the resultant increase in temperature. The objectionable consequences of this condition are obvious. The deterioration of the coils will be accelerated if there is a trace of acid in the fuel. Apart from the disadvantages cited, electricity is rather expensive for this purpose and is, of course, out of the question in the case of an isolated plant when starting up cold.

Preheating by means of the exhaust gases from the engine through a connection tapped from the main exhaust pipe is common and is generally satisfactory, but has the disadvantage that in the course of time carbon is likely to accumulate to a greater or less extent. The installation should have the coil exhausting into the main exhaust pipe, preferably fitted with a simple type of aspirator to insure that circulation obtains through the coil. This method, of course, requires an auxiliary equipment for starting.

In all cases it is advisable to have the service tank well above the level of the fuel pump, say with the bottom on a level with the engine exhaust manifold. It should be on an accessible platform and fitted with a gage glass either in one piece or in sections and a calibrated scale attached alongside marked off in gallons and tenths of a gallon. A better layout is to have two tanks with a cross-connection and fitted with a two-way cock. With this arrangement it is possible to pump up one tank when the other is in service and thus insure a more accurate reading of the fuel consumption.



Air Preheating Established

A GREAT deal remains to be learned in regard to the utilization in land practice of air preheaters. From the number now operating and on order, it is evident that the existence of sound reason for their installation is quite generally accepted as a result of experiments and calculations to date.

Although air preheating offers an alternative to the economizer for the purpose of reclaiming stack losses and stage bleeding is also a competitor of the latter, inasmuch as it may be employed for raising condensate to boiler temperature, nevertheless a number of installations have been designed lately in which air heaters follow economizers. An objection to heating condensate entirely by stage bleeding is that less can be gained at high temperature extraction than for the lower range. Conditions frequently make it more economical to supply the last increment of feed-water heat from escaping stack gases, in preference to steam which has been partly expanded.

Preheating without an economizer offers interesting possibilities, though not necessarily of major importance. A flatter and higher efficiency curve that tends to result would encourage operation at higher ratings. This, of course, depends upon the ability of the fuel and furnace to withstand preheated air. In addition to the reclaimed heat a further benefit of combustion improvement may occur. Tests indicate a strong tendency to reduce the carbon content of the ash. In general, combustion and heat transfer are favored as well as the utilization of radiant heat and low-grade fuel. The type of furnace and nature of fuel, however, may be such as to militate against these advantages. As pointed out in tests made over forty years ago, preheating offers a worthwhile gain in efficiency due to heat reclaimed and improved combustion. In addition, where conditions make it possible to obtain a large degree of this gain, there are other circumstances contingent on air heating that may make it more beneficial.

Some Aspects of Specifications

SPECIFICATIONS may be in effect a two-edged sword. They may increase costs materially, introduce complications that interfere with delivery and later on make it more difficult to obtain duplication except at exorbitant cost and expensive delay. Primarily, the function of a specification is to assure the purchaser that he obtains something of known material and workmanship to accomplish a given function in a given way within fairly close limits. It also protects the bidder and constitutes a common denomination for the comparison of performance and cost where more than one bid is involved.

Unfortunately, some engineers and purchasing agents feel it incumbent upon them to make their specifications as complex and complete as they know how. They introduce extraneous elements that have little or no bearing upon the ultimate purpose and serve only to increase the cost of bidding and make it the more difficult to meet the specifications. It costs money to draw up specifications just as it costs money to study them, bid on them and meet them.

As many of the factors involved may have far-reaching consequences and interrelated influences, they deserve deliberate study. The manufacturer is often much better qualified to judge of these from experience; and at all times it may be somewhat presumptive as well as shortsighted for those drawing up the specifications to concern themselves with what they are not strictly fitted to pass judgment upon. Yet these same men, after including stipulations that carry with them an expense out of all proportion to their academic or practical value, will often jeopardize their entire painstaking effort by inserting somewhere some such phraseology as "or its equivalent." This often is done where some vital factor is involved, where perhaps radical improvements plainly urge the discretion with the manufacturer.

Specifications are invaluable. They become either necessary or less necessary as standardization progresses, according to the viewpoint and what is involved. At the same time they tend to hamper development and improvement because their very bases concern known and well-established processes, materials and applications.

It will be found good practice to make specifications as short as possible, yet as complete as necessary. Leave out nothing that requires to be in and include nothing that can be omitted. In other words, state the conditions concisely and to the manufacturer whose business integrity has been established, give some leeway in meeting requirements. Trust in his wider judgment gained from daily experience may result in material benefit.

Periodic Testing of Motors Essential to Good Operation

PERIODIC testing of power equipment is something that is generally recognized even though it may not be practiced as assiduously in many plants as it should be. In the better class of steam power plants they are run practically under test at all times. However, with electrical-motor equipment except in special cases, it is not necessary to have a daily record of operation, but the machines should be tested and records made every three or six months. Not only the motors, but also the machines that they are driving may get out of order and cause unnecessary power consumption or injury to the equipment. These defects generally can be detected and repaired if tests are made on a proper schedule. In this way excessive power consumption is prevented, repairs are made at a minimum cost, and most impor-

tant, costly interruptions to production may be prevented.

Testing motors periodically brings to light a surprising lot of information that otherwise would probably never be known. It also creates an incentive at regular intervals to study carefully the machine's operation in a way that could not be done without the data obtained from instruments. Not only does this apply to power consumption but also to tests of the machine's insulation.

Where a motor is driving a lineshaft from which a number of machines are driven by belts the tension in the belts may be made so great as to cause a considerable increase in power consumption, or additional machines may be added until the motor is over-loaded, without anyone being aware of the fact unless careful check is kept on operation. Pumps and compressors may take greatly increased power to do a given work unless the valves and thrust bearings are kept in proper condition. It is not an uncommon occurrence for the thrust bearings on a centrifugal pump to have worn where they caused the motor to be overloaded and burned out before anyone realized that there was any trouble with the machine.

On elevator machines not only the condition of the equipment but the quality and quantity of lubrication used has a marked effect on the power consumption. A grade of lubricant that will give satisfaction in the warm season may be unsuitable during the cold period. Worn thrust or drum-shaft bearings on drum-type machines may cause an increase of power. These are easily detected if proper records are kept of the machine's operation.

To obtain the maximum results from tests, it is essential that careful record be kept of the information thus obtained. It is by comparing the records of one period with that of another that may show irregularities in machine operation that would pass unnoticed. In other words, periodic testing of motors is the only way to get thoroughly acquainted with the machines.

The Muscles of Power

THE "food" of power is the energy stored in fuel or falling water; its "muscles" are the metal tubes, rods, cylinders, pistons, etc., that guide this energy into useful channels. When the oxygen of the furnace air meets the furnace fuel, refractories must be ready to throw a fence around the fierce heat of the gases while the boiler is soaking it up. The boiler tubes must stand firm under an internal bombardment of steam molecules, as must the superheater, steam main and engine cylinder. The piston, sliding smoothly yet snugly in its cylinder, must transform this hail of molecules into a single moving force passing through piston rod and connecting rod to crank and flywheel. Or, if you will, the nicely curved surfaces of turbine blades must catch the energy of swiftly moving steam jets and deliver it through disks or drum to spinning shaft and generator.

Wherever one looks in the power plant, these muscles are at work. None of them may fail if service is to be maintained.

In the early days of power plants, and in fact up to recent times, all necessary requirements as to the strength of these muscles of power were met by a few standard materials: Wrought iron, cast iron and soft steel, with occasional applications for copper, brass, bronze, babbitt and tool steel—all of which had been available for years. After the energy had passed the boiler furnace, no temperatures were encountered at any point of the power cycle that appreciably weakened the materials used. The moderate forces existing were easily handled by taking care to supply enough metal in the proper place.

This happy state no longer exists. During the last few years the eyes of engineers have been opened to the increased thermal efficiency obtainable by the use of higher steam pressures and superheaters. This at once raised the question of the effect of high temperatures upon the ultimate strength, elastic limit and yield point of metals, and particularly of the ferrous metals.

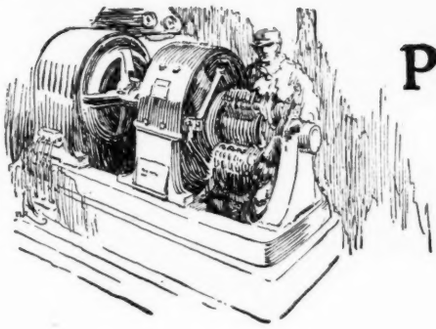
The boiler tubes, being subject only to saturation temperatures, which are moderate even at very high pressures, did not present a difficult problem, but the materials available for superheaters, steam mains, valves, fittings, pipe joints and those parts of engines and turbines exposed to high-pressure superheated steam, bade fair to set a definite limit on the utilization of high temperatures.

The first material to go by the board for high pressures and temperatures was cast iron, largely because of its low tensile strength and tendency to "grow." It was generally agreed that steel must replace cast iron for all parts exposed to high pressures and temperatures.

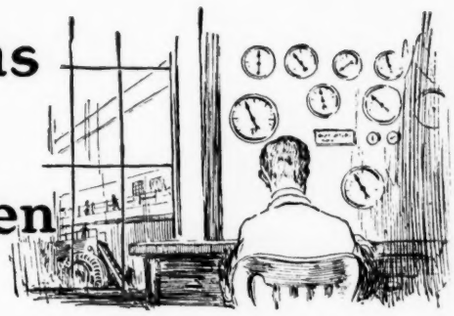
But that was just a start. There were many kinds of steel. Aside from ordinary low-carbon machine steel many alloys, developed for other purposes, were on the market. Their properties were studied, and it was found that by the use of the best available materials steam temperatures might safely be carried up to about 750 degrees F. There the matter rests today.

Advance beyond this point must evidently await the genius of the metallurgist. The problem is undoubtedly a difficult one, yet power-plant engineers will continue to hope that the metallurgists who have made such remarkable advances during the past twenty years, will not throw up the sponge at this obstacle. When the new metals are forthcoming, assuming that they are reasonable in cost and otherwise suitable for power-plant equipment, the power experts will undoubtedly be ready to throw the seven hundred and fifty-degree limit into the discard and pass on to an era of still higher efficiency.

Those imbued with the true engineering spirit cannot but admire the bold stand for freedom of discussion taken by George Otis Smith in his address on November 20 before the Metropolitan Section of the A.S.M.E. Doctor Smith, who himself is an ardent opponent of government ownership and operation, at the same time deplored the fact that the atmosphere at the World Power Conference was somewhat antagonistic to free discussion of the question by advocates of government operation. He took the position, which is hardly open to criticism, that if, as he thoroughly believes, the position of those opposed to government ownership and operation is fundamentally sound, it will not be hurt by permitting the other side to state its case. He knew of business men who expressed surprise when he included in a report a paragraph unfavorable to the cause he was advocating, but he hoped the day would never come when engineers would be classed as men who were afraid to look at facts from whatever source they might be derived.



Practical Ideas *from* Practical Men



Some Uses for Aluminum Bronze Powders in the Power Plant

Aluminum bronze powders mixed with ordinary cup grease such as can be found in any engine room make an excellent paste, which can be used for many purposes. In our engine room we always have a can mixed ready for use. When we repack the engines we grease the packing thoroughly with the aluminum paste. It has been our experience that the packing lasts twice as long and is steam and water tight, with much less tension, and the rods take on a fine polish.

We use asbestos gaskets wherever possible. These are always served with aluminum grease, and in no case have we had a leaky joint. We also use this grease for all pipe joints, whether steam, air or hot water and on the steam chest and cylinder covers of our engines.

We mix the paste ourselves by hand, adding the aluminum to the grease till it is of the right consistency.

SWINEY MORGAN.

O'Fallon, Ill.

Starting Synchronous Motor When Line Voltage Is Low

Contrary to what is generally believed, a synchronous motor does not always take a heavy current from the line when starting. Slow-speed motors may take less current at starting on full voltage than high-speed motors will on part voltage. For example, a 1,000-r.p.m. motor on 60 per cent line voltage will take about the same starting current as a 100-r.p.m. motor on full line voltage. Each will take about 225 per cent full-load current.

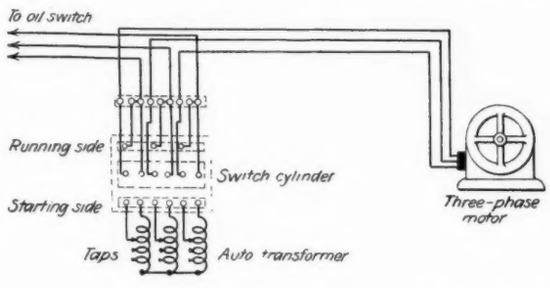


Fig. 1—Compensator connections to reduce line volts

A slow-speed 2,200-volt synchronous motor was installed to drive an ammonia compressor, and when installed, satisfactory starting was obtained on the high taps of the compensator. which gave about 80 per cent line voltage. As time went on, the voltage regulation of the line became very poor and it also became desirable to get a greater starting torque than could be obtained on 80 per cent of 2,200 volts. However, the line voltage at times was less than 1,900. Connecting the motor directly to the line did not give the desired results on account of the low voltage that was experienced.

This difficulty was overcome by reversing the compensator connections so as to make it step the voltage up instead of down. The connections before and after the change are shown in Figs. 1 and 2 respectively. The connections on the auto-transformer coils were reversed so as to obtain the lowest boosting tap, which gave about a 20 per cent increase in voltage. When the voltage of the line was above 2,000 volts, the motor was started directly from the line by throwing the compensator to the starting position before closing the line oil switch. Starting, with the line voltage less than 2,000, was done by first closing the oil switch and then throwing the compensator to the starting position, which boosted the voltage. On account of the increased drop in the line the voltage at the motor terminals at starting was in no case much above normal rating.

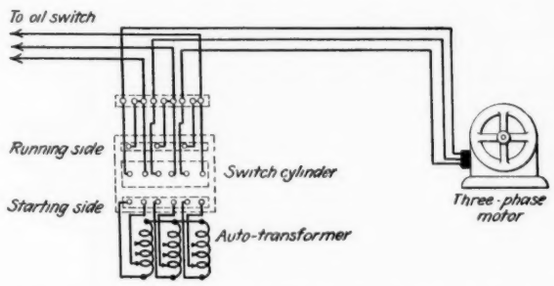


Fig. 2—Compensator connections to increase line volts

A. A. FREDERICKS.

Philadelphia, Pa.

Measuring Condenser Leakage with a Megger

The conductivity method of condenser leakage determination is not new, but has been used for some time by stations using sea water for cooling water in condensers. Owing to the great difference in conductivity of the sea water and the condensed steam, the leakage can be easily determined with reasonable accuracy. However, in the inland plants the conductivity of the river water used for condenser cooling is so low that an improvement on the ordinary method is required to obtain the desired accuracy in results.

As is generally known, even the purest water is slightly conductive to electric currents. Due to the gases and other matter carried into the condenser with

the steam, the water condensed from the steam is even somewhat more conductive than pure water. To determine accurately the condenser leakage, it is therefore necessary to have a sample of the condensed steam. This sample is collected in a small condenser which is attached to the exhaust section of the turbine. Fig. 1 shows how the connections to the turbine are arranged. Condensers of this type can be purchased for about $9.

The inlet *a* of the coil is connected to the second from the last stage steam supply, and the outlet *d* of the coil to the exhaust section of the turbine, to insure a circulation of steam through the coil. The necessary cooling-water supply is furnished through the connections *b* and *c*. At *e* a flask is conected as shown, for the collection of the sample.

Samples should be obtained both of the condensed steam and of the condensate from the main condenser at the discharge side of the condensate pumps. These two samples should be taken one after the other as rapidly as possible and preferably at a time when the station load is not likely to vary. The cooling water is also to be sampled at this time.

The conductivity of all these samples is then determined by the use of the apparatus shown in Fig. 2. The glass tube used is preferably of pyrex glass which has been allowed to stand for two days in distilled or other low-conductivity water before it is first placed in service.

In each end of the tube rubber stoppers are fitted,

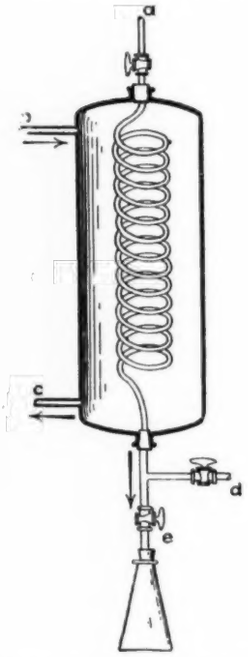


Fig. 1—Coil for condensing steam samples

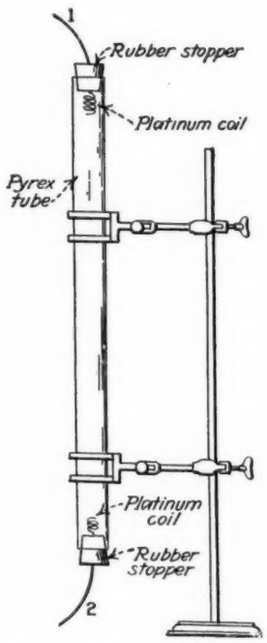


Fig. 2—Tube for measuring conductivity

through which a short piece of No. 24 B & S gage platinum wire is inserted and formed into a small coil on the inside end of the stopper. The glass tube should be of such length that the distance between the ends of the platinum coils in centimeters will be just one hundred times the inside area of the glass tube in square centimeters.

The scale on the megger that is used is graduated to show the resistance in megohms. By using a length to area ratio of 100, the megger readings can be converted into specific conductivity by dividing 100 by the actual megger reading, the conversion equation being

$$\text{Specific conductance in micromhos} = \frac{R}{\text{resistance water column in megohms}}$$

in which R is the ratio of length to area of the water

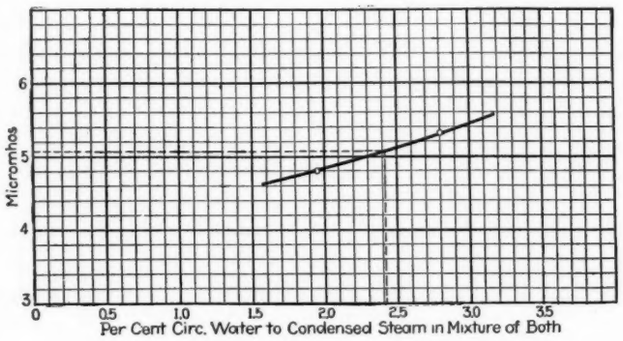


Fig. 3—Method of determining actual leakage

column. The specific conductivity is that of a centimeter cube.

From the specific conductivity of the three water samples a first approximation of the per cent leakage can be obtained by use of the equation $P = \frac{C_c - C_s}{C_r - C_c}$ where P is the ratio of circulating water to condensed steam, C_c is the conductivity of condenser condensate, C_s is the conductivity of condensed steam, and C_r is the conductivity of river water.

A mixture of condensed steam and circulating water should then be made having the same ratio of cooling water to condensed steam as was given by the solution of the foregoing equation. If this mixture has the same conductivity as the main condenser condensate water, the percentage of condenser leakage is the same as the ratio of circulating water to condensed steam in the previously made mixture, expressed as a percentage.

If, as is probable, the conductivity of the mixture is greater than that of the condenser water (condensate), a new sample should be made having a slightly smaller percentage of circulating-water content. As the conductivity of a solution varies almost directly with the temperature, care should be taken that all determinations on the solutions are run at the same temperature.

When two samples have been made up, one of which gives a higher and the other a lower conductivity than that of the main condenser condensate, the percentage of leakage can be determined by plotting these two conductivity values against the percentage of circulating water in the respective mixtures, as shown in Fig. 3.

After the operator has had some experience making leakage determinations, he will not need to work out the equation for the first approximation of the leakage, as he will be able to estimate an approximate value for use in making up the first test without the use of the equation.

In cases where it proves impossible to determine the circulating-water conductivity, it will be somewhat more difficult to arrive at a first approximation of the leakage for use in making the first trial mixture of circulating water and condensed steam, but the leakage determination, when finally arrived at, will be none the less accurate.

HAROLD EDWARDS.

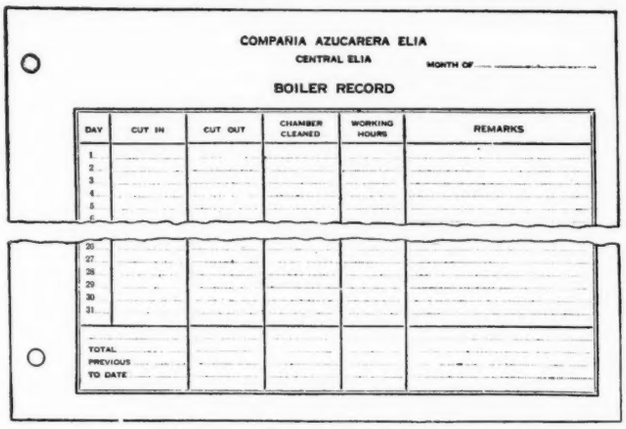
New Kensington, Pa.

Comments from Readers

Boiler-Room Logs

In the issues of *Power* for Sept. 23 and Oct. 7 are interesting articles on the use of boiler logs. I have always advocated the use of logs for different purposes, and I started a daily and monthly log sheet for the boilers at this central as soon as I took over the duty as first assistant engineer. Reproductions of these log sheets are shown in Figs. 1 and 2.

The boiler-room log that is written up every day gives information regarding the boilers in use, time cut in


COMPAÑIA AZUCARERA ELIA

CENTRAL ELIA MONTH OF _____

BOILER RECORD

DAY	CUT IN	CUT OUT	CHAMBER CLEANED	WORKING HOURS	REMARKS
1					
2					
3					
4					
5					
6					
20					
27					
28					
29					
30					
31					
TOTAL PREVIOUS TO DATE					

Fig. 1—Monthly log sheet

or out, number of hours in use, and if out of regular turn, why they were cut out and the work necessary to put them on the line again. This information is then transferred to a boiler log sheet, one being used for each boiler so that the number of hours in service, time cut in or out, chambers cleaned, and all repairs can be recorded in detail as may be required.

As we use nothing but bagasse for fuel, we do not log the amount of fuel burned. However, I think much of the data suggested by John L. McCarty in the Oct. 7 issue should be included in the daily log and transferred later to the individual boiler logs. If the equipment is at hand for measuring the fuel and water to each boiler, these items should be included.

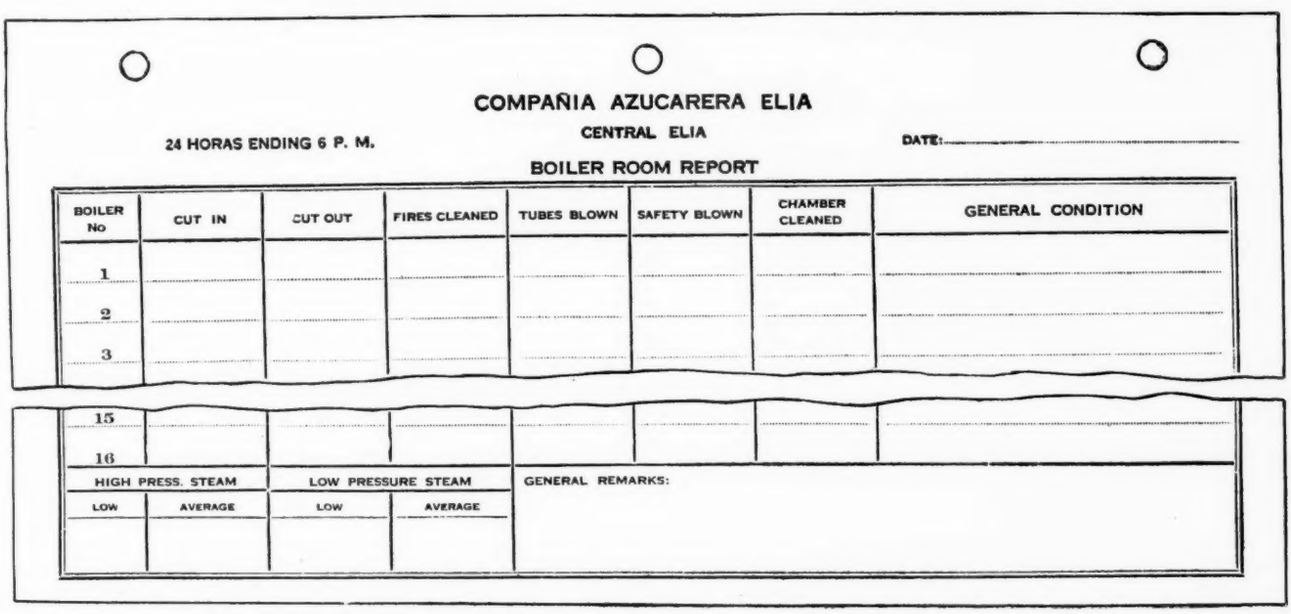
Either the card, loose-leaf or regular book can be used for the purpose, but I would suggest either the loose-leaf or card for the monthly or individual boiler report, and a book for recording the daily operation, as the items can then be put down as they happen or at the end of the day, and later transferred to the monthly log when one has the time. This arangement obviates the necessity of reading through the daybook to know the history of a particular boiler, as all the details are finally recorded on one sheet or card. EDWIN C. BLISS.

Central Elia, Cuba.

The Revival of Air Preheating

Referring to the article in the Nov. 11 issue of *Power*, entitled "The Revival of Air Preheating," I am wondering if the mention of an air heater that was tested "about forty years ago" refers to the one tested by the late J. C. Hoadley for the New England Cotton Manufacturers Association during 1882.

Mr. Hoadley, in his very exhaustive tests, sums up the results of preheating as between 9 and 15 per cent. If this is right, why has this process not become more prominent? As an advocate of preheated air for years before Mr. Hoadley's tests were made, I think this question can be answered in the light of experience. It has been mentioned in articles that have appeared in


COMPAÑIA AZUCARERA ELIA

24 HORAS ENDING 6 P. M. CENTRAL ELIA DATE: _____

BOILER ROOM REPORT

BOILER No	CUT IN	CUT OUT	FIRES CLEANED	TUBES BLOWN	SAFETY BLOWN	CHAMBER CLEANED	GENERAL CONDITION
1							
2							
3							
15							
16							

HIGH PRESS. STEAM		LOW PRESSURE STEAM		GENERAL REMARKS:
LOW	AVERAGE	LOW	AVERAGE	

Fig. 2—Daily log shows number of boilers in service and details of operation

Power from time to time, but none of them have gone far enough to fully answer the question.

In the first place, the device for preheating the air, as tested by Mr. Hoadley, was expensive to construct and maintain. The same might be said about the apparatus for handling the air after preheating. Furthermore, is it not possible that the preheated air was introduced at the wrong place? It is my opinion that it should have been introduced above the grate rather than below it.

The question for the steam user, when asked to invest in some device that will reduce his coal bill is "What net returns do I get on my investment?" and this question is of such far-searching effects that it is difficult to follow to a satisfactory conclusion. However, assuming that the customer has been guaranteed a saving of 10 per cent on his coal bill and that an evaporation test has shown that the guarantee will be fulfilled, it does not assure him that the operating costs of his power department will not be increased. Upon investigation he is likely to find that the costs of maintenance and other overhead charges have wiped out the gains that he anticipated from increased evaporation. As an illustration, take the case of the so-called Thompson boiler which on tests made by well-known experts, showed such remarkably high efficiency that it caused much comment. Why was this boiler never put on the market? Was it not because of the revolving grate that was carried on ball bearings and the excessive cost of maintenance?

Recently, technical publications have devoted considerable space to the subject of air preheaters, but they do not lead to a proper understanding of this subject. The important question is, What has it cost to get this higher efficiency?

However, there is a method of obtaining preheated air without any expensive apparatus. This can be done with an appliance that any fairly good mechanic can readily construct. As *Power* has frequently referred to this matter and published illustrations of it, there is no need of saying more about it at this time, except to advise any who may be interested in this matter to look up their old copies of *Power* and learn the reason why. W. H. ODELL.

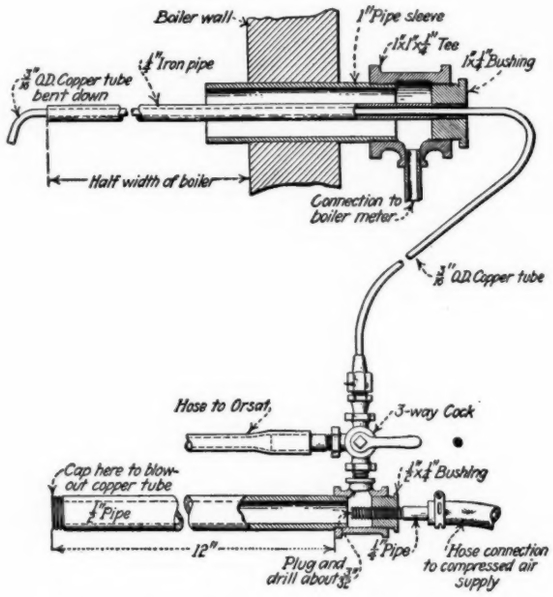
[Undoubtedly, the method mentioned by Mr. Odell in the last paragraph refers to the one illustrated and described in the Jan. 11, 1911, issue and reproduced in the Feb. 12, 1924 issue.—Editor.]

Arrangement for Taking Flue-Gas Samples

In the Oct. 21 issue M. S. Gerend describes an arrangement for drawing flue-gas samples from any one of twelve boilers. This scheme is no doubt very good where a large number of boilers are in operation, but in our plant, where the flue-gas analysis is used only as a periodic check on the boiler meters, a much simpler arrangement has proved satisfactory.

A piece of $\frac{3}{8}$-in. O. D. copper tubing is used to carry the gas from the boiler to the aspirator and Orsat. Inside the boiler the tube is supported in a $\frac{1}{4}$-in. iron pipe placed in a sleeve in the boiler wall as shown. The tube goes into the boiler in the last pass just under the damper and is made to reach halfway across the boiler into the middle of the gas stream. The copper tube extends beyond the end of the iron pipe about 6 in. and is bent down to avoid drawing any air that may enter through the iron pipe.

The aspirator is made from pipe fittings and is operated by compressed air. In one position of the three-way cock the Orsat is cut off and the aspirator draws the flue gas and discharges it into the air. This keeps fresh gas in the tube at all times. By turning the cock to the opposite position, the aspirator is cut off and the Orsat is connected to the tubing and a sample is drawn in by lowering the leveling bottle. At intervals the end of the $\frac{1}{2}$-in. discharge of the aspirator



Arrangement of Orsat and aspirator connections

is capped and the compressed air is discharged through the copper tube to blow it free of dust.

The aspirator is suspended from the $\frac{3}{8}$-in. copper tube and the Orsat and air connections are made with rubber hose. This arrangement has proved satisfactory because of its simplicity and because the time lag is reduced to a minimum. C. N. HUTCHINSON.

Albany, N. Y.

Preheating of Boiler-Feed Water

There are two general ways of preheating boiler-feed water—by using an economizer and by preheating with steam. It is at least confusing to consider an economizer as a separate part of the boiler and to call this heating-surface a preheater for feed water.

The boiler-heating surface, as well as the so-called economizer surface, has the purpose to transmit heat from the flue gases to the water. The difference is that the economizer tubes are completely filled with water, while the boiler tubes are partly filled with steam. There is a wide difference of opinion as to the proper division of the heating surface of a boiler. One manufacturer, who perhaps does not furnish cast-iron economizers, may designate 80 per cent of the whole surface as boiler surface and the remaining 20 per cent as economizer surface, while another might place these at 60 and 40 per cent respectively. In both cases, when calculating the boiler ratio, the boiler-heating surface only is usually considered, which results in a higher ratio in the latter case, although the amount of steam generated will be the same in both cases.

For any two boilers, one with an economizer and one

without, but with the same total heating surface, the same diameter of tubes and equal stokers on which the same amount of coal is burned, the difference in the amount of steam generated will depend principally on the furnace design, the amount of heat transferred by direct radiation from the furnace and on the water circulation. Furnaces equipped with wall water screens have given boiler ratings up to 600 per cent.

It is my opinion that any heating surface that absorbs heat from the gases, be it economizer surface, superheater surface, air-preheater, furnace-wall water screens or a waste-heat coal drier, should be considered as boiler surface and included when determining the rating. These surfaces, of course, must be converted into equivalent water-tube surface, and this conversion can be done only approximately. The factor for the conversion of air-preheater surface to water-tube surface will be about 1 to 3, or 3,000 sq.ft. air-preheater surface would correspond in thermal efficiency to about 1,000 sq.ft. of water-tube surface. The price of an equivalent air preheater and economizer will be approximately the same.

H. COERPER.

New Dorp, Staten Island, N. Y.

Correction of Bourdon Pressure Gage

The answer to the question of "J. B." in the Sept. 30, issue regarding Bourdon gages appears to me to be rather vague, and the following explanation is therefore submitted:

A Bourdon gage is so constructed that an error that increases constantly with uniform increments of pressure can be easily eliminated. The mechanism is readily exposed for adjustment by removing the glass front, the pointer and the graduated dial of the gage. A pointer jack should be used for removing the pointer, thus avoiding any possibility of bending the spindle.

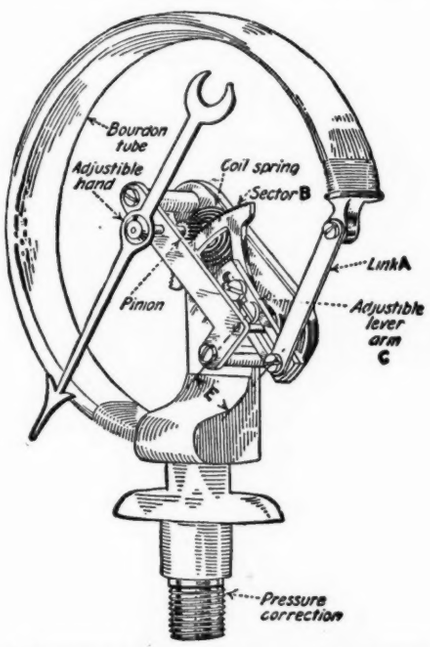


Fig. 1—Adjustment is made by sliding lever on sector

The two general types of Bourdon gages in use are the single-tube and the double-tube. In these types the connection of the pointer to the gage tube is by some form of adjustable gear and lever mechanism. In the single-tube gage this adjustment, lettered *E* on the sketch, Fig. 1, is generally one of three forms: (1) A slotted arm of the sector in which the end of the connecting link *A* from the gage tube can be moved; (2) a cam motion at end of the sector arm to which lever *A* is attached; (3) a separate sector arm *C* that is fastened to the sector *B* by screws, this separate arm being slotted for the pivot pin. Thus a change by any of these methods will change the leverage *E*, which will cause a slower or a faster movement of the pointer for any uniform increment of pressure.

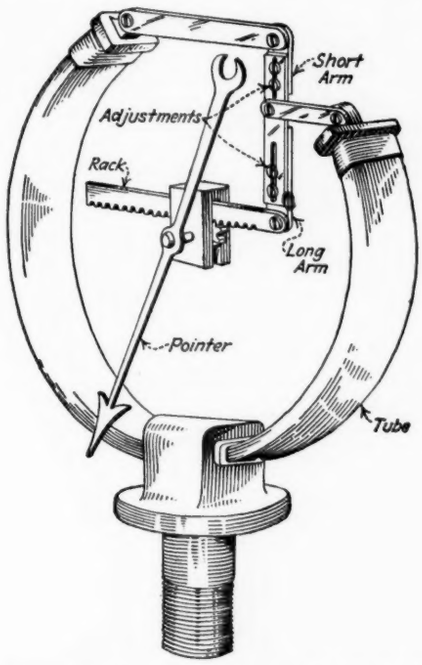


Fig. 2—Gage reading is corrected by changing adjustment of short or long arm

In the double-tube type there are two adjustments as shown in the sketch, Fig. 2, one in the short arm and one in the long arm. The uneven variation that cannot be taken care of in the single-tube gage may be to some extent eliminated in this type, as in a case when the pointer increases too fast in the upper range of the gage and too slow in the lower range. One or both of the adjustments may need altering before the gage hand or pointer will run up evenly with that of the testing device.

A hairspring on the pivot pin is generally used to take care of any lost motion in the gear or leverage and also helps to dampen out slight vibrations.

The pointer should not be replaced upon its spindle until a pressure sufficient to give a reading of the gage near the center of its range has been applied to the gage tube. This pressure being known, the pointer should then be pressed upon its spindle at a point on the dial corresponding to the known pressure. A number of trials may be required before a satisfactory adjustment can be obtained.

Errors at the lower and the upper limits of the gage are common and may be expected. Gages should be made to read as accurately as possible through the center of their range. For this reason they should be chosen so that the working pressure will be near the middle of their range. This will insure maximum accuracy.

GLENN E. NICHOLS.

Rochester, N. Y.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Size of Connection for Heating Unit

The manufacturers of a fan heating unit inform us that a 3-in. main is sufficient for supplying the unit with exhaust steam. The unit is provided with a 3-in. inlet on each side. Could not the size of inlets be smaller? *M. J. M.*

It is possible that the purpose of the manufacturers is to furnish an inlet on each side of the heater for use only of the one which is better adapted to the location. If the heater is to be supplied through both of the inlets, under ordinary conditions two 2½-in. connections should be ample. However, connections smaller than those provided should not be used without consulting the manufacturers.

Galvanizing Cast Iron

What is the process of galvanizing cast-iron pipe fittings? *R. N.*

First cleanse the piece thoroughly by immersing it for a few hours in a bath of 1 part of muriatic acid and 2 parts of water. Then remove the fitting and scrub thoroughly with a brush and fine sand, after which wash with hot water. When clean, dip the piece in a hot solution of ½ lb. of sal ammoniac to a gallon of water, after which dry thoroughly and dip the fitting in a bath of molten zinc. The zinc bath used for galvanizing should be so heated that it will have a clear shining surface. The dross should be skimmed off and a little sal ammoniac should be occasionally sprinkled over the surface of the molten zinc to keep it clear.

Greater Speed Required for Feed Pump

In our plant there is a duplex feed pump that supplies water-tube boilers. Of late the pump must be run considerably faster than formerly. Why must the pump be speeded up when the boilers are carrying the same load? *A. H. S.*

For the same rate of discharge the pump would have to run at higher speed if there is greater slippage from leakage of the packings of the water pistons or greater leakage of the suction or discharge valves. The useful piston displacement will be reduced and a higher speed will be required for the same discharge if the cylinders are not filled with water during a suction stroke, due to choking of the suction line; failure of suction valves to open wide enough; too much suction lift, or from taking in air along with the suction water, or if the pump becomes airbound from air liberated out of the suction water becoming pocketed in the pump cylinder or water passages. The presence of air in the cylinder usually is shown by a short jump of the piston or plunger at the beginning of a stroke.

Quality of Steam from Steam Tables

When the temperature and pressure of exhaust from a steam turbine are known, cannot the quality of the steam be determined from tables of properties of steam? *P. C. R.*

The temperature of steam that contains entrained water is the same as the temperature of dry saturated steam of the same pressure, so that the percentage of moisture cannot be known without making a calorimeter test to determine the number of B.t.u. per pound of the mixture. This should be done even if the corrected thermometer reading is very close to the saturation temperature. However, when the corrected thermometer reading is well above the saturation temperature corresponding with the pressure, clearly indicating that the steam is superheated, the heat per pound and other properties may be obtained from tables which quote properties of superheated steam of the given pressure and temperature.

Unequal Lap of Valve of Single-Valve Engine

Why is more steam lap of the valve required for the head end than for the crank end on a single-valve engine? *W. L. B.*

On account of the angularity of the connecting rod there is a larger number of degrees of rotation of the crankshaft for any fraction of stroke of the piston from the head end of the cylinder than from the crank end, and in comparison the angularity of the eccentric rod is very small. With the same lap for each end of the valve, the angular movement of the crank and eccentric necessary to accomplish cutoff would occur later in a stroke from the head end of the cylinder than in a stroke from the crank end, and to more nearly equalize the cutoff more valve lap is required for the head end.

Setting Valves of Double-Eccentric Corliss Engine

What is the method of setting the valves of a double-eccentric Corliss engine? *L. H. N.*

First remove the back bonnets from the valves. A mark made by the engine builder will be found on each valve corresponding with the opening edge of the valve, and upon the seat or the bottom of the valve chamber a mark will be found corresponding with the opening edge of the port.

Have the dashpot rods sufficiently shortened to prevent the pistons from striking when the engine is turned over. Turn the eccentrics clear around the shaft and observe whether each rocker arm swings an equal distance each side of a plumb line held in front of its fulcrum pin, and if not, equalize the motions by adjusting the lengths of the eccentric rods. Then observe whether the central mark on the wristplate swings an equal distance on each side of the middle mark on the

wristplate stud. If not, make the distances equal by adjusting the lengths of the reach rods from the rockers to the wristplates. If there is no such adjustment of either reach rod, the equalization must be made by adjusting the length of the eccentric rod. Although such adjustment of the eccentric rod may cause the rocker to swing unequally on opposite sides of its fulcrum pin, considerable variation in this respect will not materially affect operation of the valves, when there is equal travel of the wristplate on each side of its central mark.

Now detach both of the reach rods, and with the governor resting on the stop-motion pin or collar, place the wristplates in central position. Then with the steam valves hooked on, lengthen or shorten the valve rods with rights and lefts to the steam and exhaust valves, so the edges of the valves will be in line with the opening edges of their ports. Reconnect the reach rods, place the engine on a dead center, hook on the steam valves, and roll the steam eccentric on the shaft ahead of the crank in the direction the engine is to run until the valve that should admit steam begins to open, and temporarily secure the steam eccentric to the shaft. Then place the engine on the other center and if the steam valve of that end is not line on line with its port, adjust it to that position with the right and left of the rod to that valve.

To set the exhaust eccentric, place the piston at about $\frac{7}{8}$ stroke and advance the exhaust eccentric until the exhaust valve on the end the piston is approaching is nearly closed. Then turn the engine over in the running direction until $\frac{7}{8}$ of the opposite stroke is completed, and note whether the exhaust valve is nearly closed. If not, bring the valve to closing position by adjusting the length of the valve rod. Adjust the length of the dashpot rods by putting the steam-valve wristplate at the extreme travel, first to one side and then the other and adjust the length of each rod so that the hook or crab claw just engages and clears the block about $\frac{1}{16}$ in. For cutoff later than one-half stroke, the steam eccentric now must be set back of the 90-deg. position and the lead must be adjusted by the valve rods giving negative lap when the wristplate is in central position. If the eccentric is set much behind the 90-deg. position, the governor must be blocked in stopping, so that the cutoff will trip at the extreme range and not depend on positive cutoff at full stroke.

To equalize the cutoffs, block the governor at the average running position. The governor reach-rod lever then should stand at about right angles to the governor reach rod, or where there are two reach rods, it should stand at about right angles to a line drawn midway between the rods. Now place the piston at about one-third stroke from the crank end and adjust the governor reach rod to the valve at that end so the valve will be just tripped. Then place the piston at the same length of stroke from the other end and adjust the reach rod to obtain tripping of the valve at that end.

After the cutoffs are equalized, drop the governor to its lowest point and set the safety cams so they will prevent the valve from being picked up before the port is uncovered, but not so low that the valves may not be picked up when the governor is on the starting pin or collar. Also block up the governor to its highest position and see that the valves are not opened for that position, which would result from overspeeding of the engine in case of sudden loss of the load.

Measuring Velocity of Water with Pitot Tube

What is the formula for determining the velocity of water in an open stream or a pipe by means of a pitot tube? *J. W. B.*

When the small opening of the pitot tube is directed against the current in an open stream, as indicated in Fig. 1, the water rises in the vertical leg of the tube to such a height h ft. above the surface of the water that the velocity v ft. per sec. would be attained by a body falling through the height h giving $h = \frac{v^2}{2g}$ and therefore $v = \sqrt{2gh}$, where

v = Velocity of water received in impact against the tube opening, in feet per second;
g = Acceleration of gravity = 32.16;
h = Height in feet to which the water rises in the tube above the surface of the stream, or head in feet that corresponds to the velocity v ft. per second.

When a pitot tube is inserted in a pipe with water flowing under the pressure head h, Fig. 2, the water rises to a height P above the height O to which it rises in an open column or piezometer connected to a

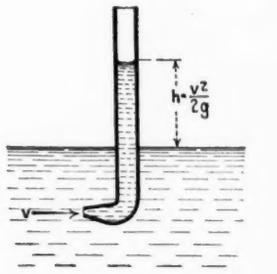


Fig. 1—Pitot tube used in open stream measurement

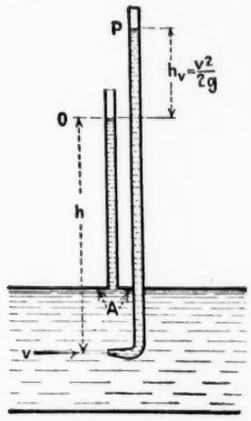


Fig. 2 — Used to determine velocity in pipe

small hole in the wall of the pipe. In that case the pitot tube shows the sum of the pressure head and velocity head, and the velocity head is $h_v = \frac{v^2}{2g}$ or $v = \sqrt{2gh_v}$.

The sides of the opening of the submerged end of the pitot tube should be a surface of revolution, and for measuring pipe velocities, the height h_v should be observed with the submerged end held in different parts of the pipe section to obtained the average value for h_v, which ordinarily will be about three-tenths of the radius of the pipe from the interior. In measuring pipe velocities care should be taken that the surface of the pipe at A surrounding the opening for the piezometer should be smooth and in line with the general pipe surface. The size of the opening for the piezometer may be no more than $\frac{1}{8}$ in. in diameter, and the tube itself, about $\frac{1}{2}$-in. bore, may be inserted in a bushing or other convenient fitting made smooth and flush with the inside of the water pipe.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Table of Engineering Constants

EXISTING engineering handbooks are remarkably complete in the matter of engineering constants; this table does not pretend to compete with them in their natural field. It frequently happens, however, that the reader of technical journals and books runs across a constant, the meaning of which is not clear to him. Often there is no clue to aid him in locating it in the engineering handbooks. On this sheet a large number of the more important constants are arranged numerically (regardless of the position of the decimal point) so that a given constant may be located almost instantly. An asterisk (*) means that the constant is exact as far as given, being generally either a mathematical constant or one fixed by definition. Where the first constant given is followed by another in parenthesis, the first is the round number ordinarily used and the second the more exact value.

0* deg. C. = freezing point of water
1 = atomic wgt. hydrogen
100* deg. C. = boiling point of water at atm. press.
10.764* sq.ft. = 1 sq. meter
0.1134 hp. = available water power from 1 cu.ft.-sec. falling 1 ft.
1.134 ft. water at 62 deg. F. = 1 in. Hg. at 62 deg. F.
1,150.4 B.t.u. = Total heat sat. steam at atm. press.
11.52 lb. = theoret. air to burn 1 lb. carbon
12 = atomic wgt. carbon (C)
12.387 cu.ft. = vol. 1 lb. air at 32 deg. F. and 14.7 lb. per sq.in.
12.52 lb. = wgt. theoret. combustion products from 1 lb. C.
1,273,239* circular mils = 1 sq.in.
13.144 cu.ft. = vol. 1 lb. air at 62 deg. F. and 14.7 lb. per sq.in.
1.3410 hp. = 1 kw.
14 = atomic wgt. nitrogen (N)
1.406 = γ = ratio of C_p to C_v for air
1.4142* = square root of 2
14.223* lb. per sq.in. = 1 kg. per sq.cm. = 1 "metric atmosphere"
144* sq.in. = 1 sq.ft.
144 (143.15) B.t.u. = latent heat of fusion of ice
14,600 B.t.u. per lb. = Cal. val. of carbon (C)
14.7 (14.696*) lb. per sq.in. = atm. press.
16* ounces = 1 lb.
16 = atomic wgt. oxygen (O)
0.1689 = C_v for air
0.017138* grams per liter = 1 grain per gal.
17.138* ppm = 1 grain per gal.
1,728* cu.in. = 1 cu.ft.
1.7321* = square root of 3
1.8* B.t.u. per lb. = 1 kg. calorie per kg.
1.8* Fahrenheit degrees = 1 Centigrade degree
18 = mol. wgt. water (H_2O)
2,000* lb. = 1 short ton
2.0355 in. Hg. at 32 deg. F. = 1 lb. per sq.in.
2.0416 in. Hg. at 62 deg. F. = 1 lb. per sq.in.
2,116.3* lb. per sq.ft. = atm. press.
212* deg. F. = boiling point water at atm. press.
2.2046 lb.* = 1 kg.
223.8* × sq. root adiabatic heat drop = theoret. vel., ft. per sec., of steam expanding through nozzle
2,240* lb. = long ton
2.3026* × $\log_{10} a = \log_e a$
2.309 ft. water at 62 deg. F. = 1 lb. per sq.in.
231* cu.in. = 1 gal.
0.2375 = C_p for air
2.54* cm. = 1 in.
2,545 (2,547) B.t.u. per hr. = 1 hp.
2.666 lb. = wgt. oxygen required to burn 1 lb. carbon
27* cu.ft. = 1 cubic yard
—270 deg. C. = absolute zero
2.7183* = e = base hyperbolic logs.
27.71 in. water at 62 deg. F. = 1 lb. per sq.in.
277.274 cu.in. = 1 British gal.
28 = mol. wgt. nitrogen gas (N_2)
28 = mol. wgt. carbon monoxide (CO)
28.8 = equivalent mol. wgt. of air
288,000* B.t.u. per 24 hr. = 1 ton of refrigeration
29.921* in. Hg. at 32 deg. F. = atm. press.
3* ft. = 1 yard
30 in. Hg. at 62 deg. = atm. press. (very closely)
3.1416* = π (Greek letter "pi") = ratio circumference of circle to diameter = ratio area of circle to square of radius
32* deg. F. = freezing point of water = 0 deg. C.
32 = atomic wgt. sulphur (S)
32 = mol. wgt. oxygen gas (O_2)
32.5* gal. = 1 barrel
3.2808* ft. = 1 meter
33,000* ft.-lb. per min. = 1 hp.
33.947 ft. water at 62 deg. F. = atm. press.
3,415 B.t.u. = 1 kw.-hr.
3.45* lb. steam "f. & a. 212" per sq.ft. per hr. = rated boiler evaporation
34.56 lb. = wgt. air to burn 1 lb. hydrogen (H)
35.314* cu.ft. = 1 cu. meter
3.785* liters = 1 gal.
39.37* in. = 1 meter = 100 cm.
3.9683* B.t.u. = 1 kg. calorie
4,000 B.t.u. (4,050) = cal. val. of sulphur (S)
4.32 lb. = wgt. air req. to burn 1 lb. sulphur (S)
0.433 lb. per sq.in. = 1 ft. of water at 62 deg. F.
44 = mol. wgt. carbon dioxide (CO_2)
0.45359* kg. = 1 lb.
—460 (459.6) deg. F. = absolute zero
0.47 B.t.u. per pound per deg. F. = approx. specific heat of superheated steam at atm. press.
0.491 lb. per sq.in. = 1 in. Hg. at 62 deg. F.
5.196 lb. per sq.ft. = 1 in. water at 62 deg. F.
5,280* ft. = 1 mile
53.32 = R, for air, in equation: $PV = MRT$
550* ft.-lb. per sec. = 1 hp.
57.296* deg. = 1 radian (angle)
58.349* grains per gal. = 1 gram per liter
59.76 lb. = wgt. 1 cu.ft. water at 212 deg. F.
61.023* cu.in. = 1 liter
62,000 B.t.u. = cal. val. (higher) hydrogen (H)
0.62137* miles = 1 kilometer
0.062428* lb. per cu.ft. = 1 kg. per cu. meter
62.5 (62.355) lb. = wgt. 1 cu.ft. water at 62 deg. F.
7,000* grains = 1 lb.
0.0735 in. Hg. at 62 deg. F. = 1 in. water at 62 deg. F.
746 (745.7) watts = 1 hp.
7.5 (7.4805*) gal. = 1 cu.ft.
760* millimeters Hg. = atm. press. at 0 deg. C.
0.07608 lb. = wgt. 1 cu.ft. air at 62 deg. F. and 14.7 lb. per sq.in.
778 (777.5) ft.-lb. = 1 B.t.u.
0.7854* (= 3.1416 ÷ 4) × diameter squared = area circle
8 = lb. oxygen required to burn 1 lb. hydrogen (H)
8.025* (= square root of $2g$) × square root of head (ft.) = theoretical velocity, ft. per sec.
0.08073 lb. = wgt. 1 cu.ft. air at 32 deg. and 14.7 lb. per sq.in.
8-⅓ (8.3356) lb. = wgt. 1 gal. water at 62 deg. F.
8,760* hr. = 1 year of 365 days
88* ft. per sec. (min.) = 1 mile per min. (hr.)
9* sq.ft. = 1 sq.yard
0.0929* sq. meters = 1 sq.ft.
970.4 B.t.u. = Latent heat of evap. of water at 212 deg. F.

SPECIAL ABBREVIATIONS

approx. ..... approximate
atm. pres. .. standard atmospheric pressure
av. ..... average
cal. val. ..... calorific value
C_p ... specific heat at constant pressure
C_v ..... specific heat at constant volume
cm. ..... centimeters
diam. ..... diameter
evap. ..... evaporation
gal. .....
gallons (U. S. unless otherwise specified)
in.Hg. ... inches of mercury (pressure)
kg. ..... kilograms
$\log_{10}$ ..... logarithm to the base 10
$\log_e$ ..... logarithm to the base "e"
min. ..... minute
mol. wgt. ..... molecular weight
pres. ..... pressure
req. ..... required
sat. ..... dry saturated (steam)
sec. ..... second
sup. ..... superheated
vol. ..... volume
wgt. ..... weight

Large Oil Engines, With Special Reference to the Double-Acting Two-Cycle Type*

By CHARLES EDWARD LUCKE
Professor of Mechanical Engineering Columbia University

There never has been any doubt about the high thermal efficiencies of Diesel oil engines, and such doubt as once existed as to their reliability or maintenance costs have been completely dissipated by the success of the motorship, which has been as great in its way as that of the automobile on land and of aircraft above.

Of the big-engine questions of broader significance, perhaps the two that stand out or are most often heard are: How may the zone of economic use be widened for such Diesel engines as have become more or less standardized as to design or size; and, second, how large, how much larger than these standards in horsepower capacity, may good oil engines be built.

The Questions of Weight

Widening of the scope of economic utility of large oil engines in existing sizes, whether in marine or in stationary fields, is mainly a question of reduction of cost. Reduction of cost is primarily a matter of weight reduction in pounds per horsepower, except when it is accomplished by the use of special high-priced materials or when it requires excessively expensive shop operations or higher ratios of labor to material in the building of the engine.

A second set of engineering problems in connection with large engines is concerned with the determination of maximum possible horsepower per cylinder, and of the means whereby horsepower per cylinder may be made greater without loss of other good qualities, and preferably also with reduction of weight and first cost.

Four-Stroke Cycle Engines

Efforts to reduce the weight per horsepower of single-acting four-stroke-cycle engines have extended over many years and still continue. Here two quite independent lines of attack are recognized in addition to the perfectly obvious one of increased speed with its limitations of life above recognized values for piston speed. The first of these is concerned with securing higher mean effective cylinder pressures. The second is directed toward the metal and its weight in pounds per cubic inch of cylinder, measured by the product of area, stroke and number.

Increase of indicated mean pressure is being secured in various ways, among the most notable of which are the following: Higher spray-air pressures to carry fuel to the more remote points of the air charge and by agitation of the whole charge to effect the combustion of more fuel per pound of air than otherwise, reducing free oxygen in the exhaust to the lowest possible value with no carbon monoxide; extra spray air injected at points other than the spray value to increase turbulence; two spray valves instead of one to reduce the distance the fuel must travel to find its air, and to reduce the necessity for extra turbulence; supercharging to increase the weight of air for a given piston displacement and so to raise the mean pressure for the same completeness of oxygen utilization by fuel as shown by free oxygen in the exhaust, it having been employed with and without the former means of raising mean pressure.

*Abstract of paper presented at annual meeting of A.S.M.E., New York, Dec. 1 to 4.

Indicated Mean Pressures

By research along such lines it has been found possible to secure indicated mean pressures of 150 lb. per sq.in. without supercharging, and 176 lb. per sq.in. with supercharging. It is fair to say that the usual values for indicated mean pressures are 60 per cent—more or less—of those proved by research to be obtainable.

It has been definitely established that combustion conditions can be secured in two-cycle cylinders which are quite as good as in four-cycle. It has also been proved that air charging of the two-cycle cylinders by ports with no head valves whatever can give air charges necessary for such equalization of mean indicated pressures if the scavenging is properly done. Therefore heads may be so simplified, compared with multi-ported four-cycle heads, as to be able to withstand uninjured the higher heat rates typical of the two-stroke-cycle engine of bore equal to the four-stroke-cycle. This is a most important accomplishment because it contributes directly to the attainment of both ideals at once: the reduction of weight per horsepower and large horsepower per cylinder; but whether the amount of these gains is sufficient is yet to be seen, as is also the question of still other means of approach.

Substantial Weight Saving by Two-Stroke Cycle

For such single-acting two-stroke-cycle engines, indicated mean pressures for the full stroke have reached the value of 122 lb. per sq.in. with an effective stroke of 77 per cent, making equivalent mean pressure 158 lb., which checks well against the four-cycle maximum values. As in the case of the four-cycle, however, the rating values are lower, Sulzer using the value of 93 lb. per sq.in., equivalent for same port lengths to 120 lb. per sq.in. for cylinders of about the same bore—between 20 and 30 in. While two-cycle operation causes some increase in weight per cubic inch (about 0.5 lb.), there is a substantial reduction made in weight per horsepower by doubling the impulses.

Finally, there is to be noted in this series of efforts to reduce weight still another and the most recent—doubling the number of impulses by the double-acting method, with its parallel of double opposed pistons. A double-acting piston should give nearly twice the output obtainable from the single-acting, either two-cycle or four-cycle, with not much increase in weight over the standard single-acting crosshead designs, provided combustion conditions are equal and permit of equal indicated mean pressures. This mode of decreasing weight per horsepower does not at all increase the heat-generation rate over the single-acting because each end acts independently. Therefore it not only contributes something to the first ideal of cost reduction through weight, but, unlike other directions of effort, it contributes quite as much to increasing the horsepower per cylinder and the maximum practicable horsepower of the engine.

Double-Acting Engines

Piston rods have not been avoided by all designers seeking to double the output of a cylinder, nor have they ever proved dangerous or even troublesome where used, beginning with the well-standardized double-acting gas engines. It is therefore of special interest to follow the piston-rod type or normal double-acting-engine development, especially as to ideas involved. Toward the end of the period of perfecting the large double-acting gas engine, practice settled down to the adoption of the four-cycle horizontal tandem arrangement, the two-cycle having been abandoned because of the losses of gas at exhaust ports during scavenging and in spite of its greater simplicity of mechanism even with valve scavenging. Design had become pretty well standardized and service reliability well established.

Vertical Designs

The vertical designs, inherently light, are of special interest, especially those that are operating two-cycle, in view of their greater simplicity and their attainment of maximum possible number of impulses with consequent promise of least weight per horsepower, as well as maximum horsepower per cylinder, subject to proof that piston rods will give no trouble, that cylinder heads are safe, and that cylinders working in both ends can be held so as to permit complete freedom of expansion of heated parts. To this must be added, also subject to proof, that combustion conditions can be as good in double- as in single-acting, it already having been established that they can be as good in two-cycle as in four-cycle, and that side-port scavenging gives as good an air charge as a four-cycle, so that nothing can be gained by the end-to-end scavenging of the opposed-piston engines.

For similar construction details and materials, that is, similar machine design, the double-acting engines will weigh a little more per cubic inch of stroke volume than the single-acting, and the excess may be greater for two- than for four-cycle, because the cylinder must be longer.

Thermal Efficiency of Secondary Importance

It is established that the double-acting, two-cycle arrangement offers the greatest prospect for both weight reduction per horsepower and increase of horsepower per cylinder, unless it should appear to be necessary to reduce mean pressures below values established for single-acting engines. It is also established that as small a number of cylinders as two will give satisfactory turning efforts with crank-shaft loads, and hence shaft sizes, that compare favorably with those on steam engines when the oil engine is two-cycle, double-acting, so that this arrangement gives a very short length of engine, other things being equal, even with allowance for scavenging pump and compressor at one end.

It has been pointed out that the really important thing in widening the scope of the economic utility of the oil engine is reduction of weight, and through it reduction of cost per horsepower on the one hand, and an increase in the horsepower per cylinder, preferably by the same means, if possible. Thermal efficiency is of secondary importance.

The indicated mean pressure of the thermodynamic cycle representative of the Diesel process of transforming heat of hot gases into work, is a function of the cutoff as in the unaflow steam engine, the diagram of which is identical except for the slope of the compression and expansion lines due to differences in fluids. It may be assumed that the maximum pressure is the same for all Diesel engines and with it the compression ratio, and for purposes of comparison this pressure may be set at 500 lb. per sq.in. above atmosphere. On this basis, and assuming adiabatic compression and expansoin of gases having the physical constants of air, the indicated mean pressures are found by circulation to be as shown in the table.

Fuel consumption per net or brake horsepower-hour will be determined by the mechanical losses, and as these are less in the double-acting than in the single-acting engines, it must follow that double-acting engines are more efficient than single-acting.

DIESEL AIR-CYCLE MEAN PRESSURES

Cut-off, per cent displacement	3	6	9	12	15	18
Mean pressure, lb. per sq.in	17.15	34.16	50.76	67.50	83.95	99.70
Cutoff, per cent displacement	21	24	27	30	33	
Mean pressure, lb. per sq.in	116.0	132.4	148.36	164.19	179.64	

It appears that by developing the double-acting cylinder for large oil engines, there is not only a material reduction in weight or cost for more or less identical machine design, especially frame types and materials of construction, a lesser number of cranks needed with a subsequent shortening of engine or reduction of floor space, and a very considerable increase in power for a cylinder of same bore, but that in addition there is a gain in fuel economy. It also appears that the two-cycle, double-acting engine exceeds in aggregate advantages the double-acting, four-cycle, though in the matter of fuel economy they are equal.

The use of forged steel for cylinders and pistons instead of the traditional cast iron seems by its ductility, to contribute directly to the reduction of the inner-skin injuries or local stress failure and burning, and its adaptability to the two-cycle port-scavenged cylinder, requiring no complicated ports and valve housings that would make adoption difficult or impossible, also contributes to further reduction by increasing the injection-frequency and reducing the skin-temperature peak to one-half.

The Use of Steel

There is, however, a further contribution of the steel wall toward prevention of injury of the contact surfaces through its direct effect on reduction of the temperature of the main metal mass. Such steel walls may be made thinner than cast iron just about in inverse proportion to the allowable working stresses which are three or more to one, depending mainly on the type of steel, of which there is now available a good range of choice. Other things being equal, the temperature drop would be one-third or less in steel walls than in cast iron for the same hourly rate of heat generation, or with the same temperatures that now prevail, three or more times the hourly rate would be permissible with a greater margin of metal stability, due to the ductility of the metal. Freedom from webs, ribs, or thickened sections common to castings, and especially when removable cylinder heads are used, adds still more margin.

For the present it may justly be said that the steel cylinder makes it possible to increase the horsepower per cylinder just as does two-cycle adoption compared with four and double-acting compared with single, so that the combination of steel cylinder, two-cycle and double-acting seems to offer the widest prospect at present in this direction. It has also been shown by this review that it is in about the same position as to number of cranks, shaft length, weight per horsepower, and with higher over-all efficiency than single-acting engines.

Exports of Bituminous Coal

Exports of bituminous coal from the United States during October were the second highest of the current year, amounting to 1,534,459 long tons against 1,502,829 tons in September and 1,631,804 tons in July, the high mark for 1924, according to the Coal Division of the Department of Commerce. The heavy shipments during the month in question were due to increased exports to Canada, 1,293,963 tons going to that destination as compared with 1,201,280 tons in September and surpassing the previous record monthly exports during this year of 1,203,165 tons in July.

Engineering Forging Ahead at Cambridge University

Most Americans picture Oxford and Cambridge Universities in England as places where the sons of the nobility receive the elements of ancient culture in a delightful social atmosphere. There is something in this view, but it does not tell the whole story. Cambridge, for example, has for a long while been one of the world's greatest centers of scientific research, particularly in physics. Much of the knowledge regarding the electron and the structure of the atom had its origin here. In fact both Oxford and Cambridge have for years held a high position in the scientific world, although other branches of learning have at times been more prominent.

Not only that, but the actual study of engineering has been going on at Cambridge for years. Starting in 1891 in a small way, it has steadily grown until today, as explained in a recent issue of *The Engineer*, there are about 500 engineering students at Cambridge. With the backing of prominent engineers and business organizations, the Engineering Department has been provided with a modern laboratory building for its work. This includes a heat-engine laboratory, a structures and hydraulics laboratory and an electrical laboratory, together with a number of minor laboratories and workshops.

Unlike Sheffield and Glasgow Universities, Cambridge is not situated where the students can keep in close touch with engineering practice on a large scale, yet this is not expected to be a great drawback, as the aim at Cambridge will be to develop men thoroughly trained in the fundamentals, rather than specialists in any one line. As *The Engineer* puts it, "Cambridge is specializing in general knowledge."

"The water-tight compartment system of education, whereby subjects are dealt with separately and in succession, is likewise discouraged. The various subjects are all worked at simultaneously, with a view to showing their inter-relation. In the first year's course the subjects are naturally treated in an elementary manner, and a considerable portion of the teaching at this stage is directed toward working students up to a certain standard in mathematics and mechanics."

One Examination Covers Three Years Work

The article goes on to describe the courses in the succeeding two years of the three-year course. "In the Tripos examination, by which a student graduates with honors, he is tested as to his knowledge over the whole range of subjects dealt with in his three years' course. . . . A student who does well in this comprehensive examination is not at that stage a specialist in any branch of engineering, but, on the other hand, his mental balance is such that he can launch forth with equal facility in any direction, and when he ultimately takes up some definite line of work his broader education and greater versatility will enable him in most cases to overtake and outdistance the man who has been a specialist from the start of his engineering education."

Secretary of Commerce Hoover Outlines Work Done by Department

Takes Up Elimination of Waste in Industry—The Coal Industry—Interconnection of Electric Power Systems

"ELIMINATION of national waste" is the keynote of Secretary Hoover's annual report, made public at the Department of Commerce on Nov. 28. He reviews the accomplishments of the Department during the first three years of the present administration, notably in the fields of unemployment, seasonal construction, coal, superpower, standardization, simplified practice, co-operative marketing, and the reduction of housing costs.

Of the bituminous coal industry Mr. Hoover says:

"Through co-operation of trade associations of the principal industrial consumers, through chambers of commerce and public utilities a large amount of regular summer storage has been induced."

The report deals extensively with the steps taken by the Secretary to further the interconnection of electric power and lighting systems. He says:

"Engineering science has brought us to the threshhold of a new era in the development of electric power. This era promises great reductions in power cost and wide expansion of its use. Fundamentally, this new stage in progress is due to the perfection of high voltage, longer transmission, and more perfect mechanical development in generation of power. We can now undertake the cheaper sources of power from water sources further afield, such as the St. Lawrence, and cheaper generation from coal through larger and more favorably placed coal generation plants.

"The savings in 11 states resulting from a co-ordinated and fully developed electrical power system, would by the time it could be erected, amount to a conservation of about 50,000,000 tons of coal per annum; an annual saving could be made of over $500,000,000 per annum at an additional capital outlay of about $1,250,000,000. In this area we are today producing something like 9,000,000 hp. by direct steam and individual plant generation, a substantial part of which could be transferred to central generation with great economy.

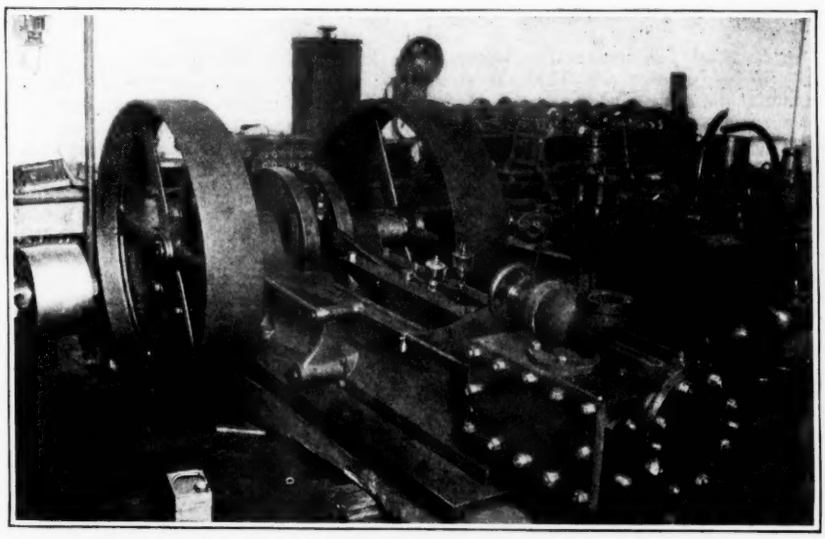
"The engineers who have made systematic superpower surveys are convinced that over 40 per cent of the mileage of the railways in this territory could be electrified at substantial economies in operation and with enlarged service if we should secure this greater and more economical power development.

"To secure the rapid adoption of these demonstratedly possible results is of profound public importance. Every time we cheapen power and centralize its production we create new uses and we add security to production; we also increase the production; we eliminate waste; we decrease the burden of physical effort upon men. In sum, we increase the standards of living and comfort of all our people."

Old Armington-Sims Engine From Sunbury in Museum

The old Armington-Sims stationary engine used by Thomas A. Edison to operate the first three-wire central station actually started and put into operation, has recently been added to the Museum of Edisonia and Historical Exhibit of Electric Lighting. The generating plant consisted of two "L" dynamos belted to a high-speed Armington-Sims engine, the total capacity being about 400 16-cp. lamps. The indicating instruments were of the crudest construction and consisted of two voltmeters which were connected by "pressure wires" to the center of electrical distribution; one ammeter interpolated in the "neutral bus," to indicate when the load was out of balance, and half a dozen roughly made plug switches.

The installation was made under the supervision of Lieut. F. J. Sprague and W. S. Andrews, and it was formally started for commercial service by Mr. Edison on the 4th of July 1883, with about 100 lamps connected. A picture of the engine, dismantled, is given below.



Old Armington-Sims engine from Sunbury, Pa., dismantled, to be installed in museum

Tecumseh, Kansas, Plant Started

The Kansas Power & Light Co., is constructing a modern power plant at Tecumseh, Kan. The initial capacity will be 15,000 kw. and a sixty-mile transmission line to Topeka and Atchison will be built to serve a population of more than 150,000. The power plant and transmission line are expected to cost in the neighborhood of $3,600,000. Both the power plant and transmission lines have been leased for fifty years.

Ten Million Power Plant Planned for Tarrytown

A $10,000,000 electric power plant to occupy 16 acres of ground on the river front at Tarrytown, 25 miles north of New York City, it is reported, is contemplated as an addition to the New York Edison system. William R. Bull, of Port Chester, said the project would be started next spring on land owned by the Tarrytown Terminal Co., which has spent more than $1,000,000 in improving the site. It is said that George F. Baker, William Rockefeller, Nicholas F. Brady and James A. Stillman are behind the project. It will be recalled that the New York Edison Co. is erecting a new station at Fourteenth St., New York City.

Government Officials Seriously Concerned Over Waste of Oil

Doherty Advocates Drastic Action by the States to Prevent Overproduction

WASTE of oil has reached such proportions that the federal government is preparing to move in an effort to prevent it. Judging from pronouncements by Dr. George Otis Smith, the government has in mind some form of co-operation with the industry to that end. Dr. Smith, in addition to his duties as director of the United States Geological Survey, is the head of the President's Commission charged with the working out of a systematic policy for the handling of naval reserves.

Since it is impossible to divorce the petroleum interests of the navy from the petroleum interests of the people as a whole, the work of the President's commission is certain to deal with the conservation of our oil resources in a broader sense.

In this connection it may be pointed out that this great problem, which is essentially engineering in character, is not being dealt with by a political group. Industry has seen so many failures on the part of politicians when they undertake to solve an engineering problem that there is universal lack of confidence in the ability of Congress to make such a determination for itself. The President's commission, however, is technical in its makeup and composed of men who, in addition to their technical knowledge, have established reputations as economists.

In addition to Chairman Smith, the membership of the commission is comprised of Admiral Hilary P. Jones and R. D. Bush. Admiral Jones is a member of the General Board of the Navy and has had specialized contact over a long period of years with the matter of oil procurement. Mr. Bush has had life-long contact with the industry and has been in immediate charge of the government of California's contact with the industry.

There is a feeling in the industry that this commission will work out a practical plan rather than recommend some form of political action which is likely to be destructive. That the commission is working along the lines of co-operation with the men in the oil industry is revealed by Dr. Smith's utterances at Tulsa. It has become increasingly evident in other quarters that the time is ripe for a larger degree of co-operative rather than antagonistic action in the production end of the petroleum business.

One straw that indicates the trend is the favorable comment in the press of the appeal for such joint action made by Dr. Smith. His contention is that, since competitive ownership is the stimulus to wasteful haste in bringing oil to the surface once a pool is discovered, regardless of the requirements of the current market, the remedy lies in co-operative action in which neighbors consult their common interest.

There is natural hesitancy on the part of some oil men, arising from doubts as to the legality of any approach toward combined or joint action, but Dr. Smith said at Tulsa that to put some limit upon excessive development and consequent overproduction would not be a combination in restraint of trade, but a combination in restraint of waste and in the public interest.

The news from Cleveland recently contained a valuable suggestion for the coal industry. Henry L. Doherty, the well-known oil and public-utility operator comes out flatfootedly, in an address before the National Petroleum Marketers' Association, for a program of legislation that would make it possible to end profligate overproduction of petroleum.

American Participants' Praise World Power Conference

If the impression received from the speakers at a meeting of the Metropolitan Section of the A.S.M.E. in New York on Nov. 20 is to be trusted, the World Power Conference, held last summer in London, is more than a past event; it is a living international force through the continuance of personal relationships there established, and the continued influence of the 300 conference papers. Addressed by John H. Lieb, vice-president of the New York Edison Co., O. C. Merrill, executive secretary of the Federal Power Commission, George Otis Smith, director of the Geological Survey, and George A. Orrok, consulting engineer — all American delegates to the World Power Conference—the meeting was called to pass on to those who stayed at home some of the impressions received.

Mr. Lieb, chairman of the meeting, showed how the World Power Conference grew out of the British Empire Exposition, which in turn sprang from the post-war desire of the British dominions for a closer economic union with the mother country.

The World Power Conference was the outward expression of economic forces manifest for several years, according to Mr. Merrill, the next speaker. The startling growth of electric power and transmission in most countries has made the matter of power resources of general interest. Europe, with fewer national resources, faces more difficult economic problems than America. There one nation may have a coal or water power beyond its present needs, while its neighbor may be practically destitute of both.

In introducing George Otis Smith, Mr. Lieb regretted the unavoidable absence of Elihu Thomson, Calvert Townley and Fred R. Low.

Like the other speakers Dr. Smith expressed deep appreciation of the royal manner in which the delegates were entertained. He showed what power meant to the mining engineer. A new supply of cheap power brought into a mining district makes "ore" of what before was only "rock." Hence, power may properly be said to increase natural resources. While water power resources should be used to the limit, the conference made it clear that mineral fuels far outrank water power in ultimate importance. Dr. Smith had only one regret in regard to the conference. While he himself was strongly opposed to government ownership or operation, mainly because of his distrust of politicians, he felt that the advocates of other policies had not found full opportunity at the conference for the expression of their ideas. Dr. Smith took the stand that engineers were interested in facts, and that they should not shut their ears to any facts that might be presented, whether or not they might be favorable to a cause they were advocating. He hoped the day would never come when the engineer would be known as a man afraid of facts.

Mr. Orrok, in the closing address, said that the World Power Conference marked a new era for the mechanical engineer. The gain is both material and social. Contacts have been established with foreign engineers that will constantly lead to mutual benefits.

Giant Power Board Asks Delay on Power Permits

The Pennsylvania Giant Power Survey Board has asked Governor Pinchot, the Public Service Commission, and the State Water and Power Resources Board to withhold approval of all requests for enlarging the privileges or rights of public service power generating, power transmitting and power distributing companies by way of charters, mergers, certificates of public convenience and necessity, approval of projects or by other means.

The board believes that the state should enter into no commitments on the subject of power development until the Giant Power Survey is submitted to the legislature next January. The Governor has announced his intention of complying with this request.

Diversion Case Arguments Before Court Dec. 1

The argument before the Supreme Court of the United States on the appeal brought by the Sanitary District of Chicago to have set aside the decision of lower federal courts requiring it to reduce the quantity of water withdrawn from Lake Michigan (known as the Chicago diversion case), which was to have taken place on Nov. 10 was postponed until Dec. 1. At this writing no information as to the court's probable action has been received. The action was taken at the request of the Solicitor General of the United States.

New York State through the Attorney-General is vigorously combating the claims of the Chicago Sanitary District, to divert in excess of 4,167 cu.ft. of water from Lake Michigan because of the serious after-effect of its contemplated program upon navigation on the Great Lakes and the St. Lawrence and the power developments at Niagara.

Water-Power Commission Issues Fourth Annual Report

Recently the Federal Water-Power Commission issued its fourth annual report for the fiscal year ending June 30, 1924. This report not only deals with the commission's work in so far as it has to do with issuing licenses and permits for water-power development, but also gives a résumé of the Northeast Superpower Committee's work and the First World Power Conference. It also discusses waterpower and navigation; waterpower and fisheries; waterpower development by public agencies under the Federal Water-Power Act; municipal ownership; customer ownership of public utility securities; and Federal Government ownership. According to the report the number of water-power projects requiring the attention of the commission continues to have a large total capacity as indicated by the following statements:

"Notwithstanding the volume of applications presented in the first three years of the administration of the Federal water power act, 87 more, involving an estimated installation of 3,325,000 hp. were filed during the fiscal year 1924, and 57 permits and licenses were issued with an estimated installation, if built, of 1,160,000 hp. There are 204 permits and licenses outstanding and aggregating 7,850,000 hp. Sixty-seven projects with a prospective installation of 2,782,000 hp. have been completed or are under construction, of which 18, with a combined installation of 259,000 hp. were started during the year. A constantly increasing part of the work of the Commission consists in the administrative duties with respect to projects already under permit or license. Preliminary permits are being changed into licenses, and licensed projects are being constructed, requiring examination of plans, inspection of construction and audit of accounts.

"No provision of the act was deemed of greater importance when the bill was under consideration in Congress than the requirement that no amount in excess of actual legitimate cost should be entered upon the books of licensees, and yet with 67 projects constructed or under construction, involving several hundred million dollars and in some instances requiring extensive valuation, and with only two accountants to perform the work, it is manifestly impossible to secure satisfactory results. It has been the experience of the Commission that overcharges to capital account are most frequently found in connection with the preliminary expenses preceding construction. So frequently has this been the case, particularly with new projects as distinguished from extensions to existing systems, that it has become the general practice to require an agreement on the total of such preliminary charges before license will be issued.

"The Commission is endeavoring to reach mutual agreement whenever possible on cases requiring valuation under section 23 of the act. It succeeded in five minor cases during the year, involving an aggregate of $581,000. Projects involving several million dollars are pending, with inventories prepared, but in the majority of cases it has not been possible to make even a beginning with the force available.

"In its third annual report the Commission called attention to the necessity of authority to employ personnel of its own if it were to be held responsible for adequately administering this most important feature of the act. It desires again to urge amendments of the law which will permit employment of personnel, which will make it possible to avoid division of responsibility in water-power administration and investigation between the Commission and the several executive departments, and which will devote to the purposes for which collected the annual charges paid by the licensees under the act."

Program for the A. S. M. E. Meetings

December 1-4, New York City

Papers of Interest to Power Plant Field

Monday morning — Council meeting; Local Delegates Conference; committee meetings.

Monday afternoon—Continuation of morning meetings.

Monday evening—Open house.

Tuesday morning — "Storage and Handling of Fuel Oil in Industrial Plants," by C. G. Sheffield and H. H. Fleming; "Handling Oil from Storage to Furnace," by John R. Battle; "Strength and Proportions of Wheels, Wheel Centers and Hubs," by R. Eksergian; "The Turbine Designer's Wind Tunnel," by H. Loring Wirt; "Test of Prosser-type Reciprocating Steam Engine," by L. V. Ludy.

Tuesday afternoon—Joint session with the American Society of Refrigerating Engineers; "Some Factors Influencing Friction, Velocity Distribution, and Heat Transmission, for Fluids Flowing Inside Pipes," by W. H. McAdams; "The Temperature of Evaporation of Water Into Air," by W. H. Carrier and D. C. Linsay; "Water-Cooling System Efficiency," by Victor J. Azbe; "The Zoelly Turbine-Driven Locomotive," by Henry Zoelly; "The Ramsay Condensing Turbo-Electric Locomotive," by George F. Jones and T. Lawrence Hale of London; "Engineers and the American Petroleum Situation," by Julian D. Sears; Public hearing on "Power Test Codes for Solid Fuels, Gas Producers, and Speed Responsive Governors," Fred R. Low, president, presiding.

Tuesday evening—Presidential address on "Power," by Fred R. Low. Reception by the society.

Wednesday morning — "Fuel Oil Burning in the United States Navy," by Lt. Comdr. H. G. Donald; "Oil Burning in Industrial-Plant and Central-Station Service," by N. E. Lewis; "Hazards of Industrial Oil Burning," by H. E. Newell; "An Investigation of Critical Bearing Pressures Causing Rupture in Lubricating Oil Films," Lt. Comdr. L. N. Linsley; "High Pressure-Bearing Research," by Louis Illmer; "A Graphical Study of Journal Lubrication," by H. A. S. Howarth; "The Engineering of National Defense," by Assistant Secretary of War Dwight F. Davis; "Hazards of Pulverized-Fuel Systems," by H. E. Newell and R. Palm.

Wednesday afternoon—Presentation of Melville bust; Presentation of Awards; Report on Steam Tables Research.

Wednesday evening — Annual dinner with Dr. Livingston Farrand, president of Cornell as the principal speaker.

Thursday morning — "Water Treatment for Continuous Steam Production," by R. E. Hall; "The Increase in Thermal Efficiency Due to Resuperheating in Steam Turbines," by E. E. Blowney and G. B. Warren; "Review of Recent Applications of Powdered Coal to Steam Boilers," by H. Kreisinger; "Recent Developments in the Burning of Anthracite Coal," by W. A. Shoudy and R. C. Denny.

Thursday afternoon — "Solid-Injection Oil Engines," by R. Hildebrand; "Large Oil Engines, with Special Reference to the Double-Acting Two-Cycle Type," by C. E. Lucke; "Gas Turbines," by L. S. Marks and M. Danilov; "Methods of Economic Design of Penstocks," by H. L. Doolittle; "Intake for Power Plant," by Robert Angus; Lecture, "Properties of Matter Under High Pressure," by P. W. Bridgman.

Thursday evening — "Carnot Centenary," Dr. William F. Durand, president-elect A. S. M. E., presiding; "Carnot's Principle," by Dr. Michael I. Pupin and "Carnot's Influence Upon Engineering," by Dr. William LeRoy Emmet.

A. S. R. E. Holds Its Twentieth Annual Meeting

The American Society of Refrigerating Engineers is holding its twentieth annual meeting, Dec. 1-3, at the Hotel Astor, New York City. The program of papers of interest to *Power* readers is:

Monday morning—Presidential address, "The Social Challenge to the Engineers," by George A. Horne; "Central Station Pipe Line Refrigeration," by A. W. Oakley.

Monday afternoon—Public hearing on "Mechanical Refrigeration Safety Code" in Room 1001 Engineering Building, 29 West 39th St.

Monday evening—"Tests on a Rotary Ammonia Compressor," by G. J. MacIntire; "The Electrically Driven Ice Plant," by Fred Ophuls.

Tuesday morning—"A Theory of Cooling Towers Compared with the Results in Practice," by B. H. Coffey.

Tuesday afternoon—Joint session with the A. S. M. E., 29 West 39th St. "The Flow of Liquids," by W. H. McAdams; "Water Cooling Efficiency System," by Victor J. Azbe; "The Temperature of Evaporation of Water Into Air," by W. H. Carrier and D. C. Lindsay.

Tuesday evening—Annual dinner and dance at Hotel Astor.

Wednesday morning—"The Specific Volume of Superheated Ammonia Vapor," by C. H. Meyers.

Wednesday afternoon — Visit to Power Show at Grand Central Palace.

Philadelphia A.S.M.E. Discusses Automatic Combustion Control

Anyone attending the various engigineering society meetings where automatic combustion control has been discussed cannot fail to be impressed by the intense interest in this subject as expressed by the large attendance and the enthusiasm with which the presentation of the papers and discussion have been carried out. The meeting of the Philadelphia Section of the American Society of Mechanical Engineers, held in the Engineers Club at Philadelphia, on Tuesday evening, Nov. 25, was no exception to previous records. The auditorium was crowded and the session lasted until after 11 o'clock.

The meeting was presided over by Section Chairman N. E. Funk, who first called upon Fred R. Low, editor of *Power* and President of the American Society of Mechanical Engineers, to address the meeting. President Low extended a hearty invitation to the members of the Philadelphia Section and their friends to attend the Annual Convention in New York and assured them that this year's program was one of the best in the history of the Society.

The subject for discussion, "Development of Combustion Control," was presented by four speakers: E. G. Bailey, president of the Bailey Meter Co.; M. G. Benjamin, president of the Benjamin Engineering Co.; Charles H. Smoot, president of the Smoot Engineering Co.; and K. L. Martin, president of The Engineer Co. Each speaker described systems of centralized automatic combustion control that had been developed by his company and were now in successful use in some of the largest plants in the country.

E. G. Bailey was the first speaker and prefaced the description of his combustion-control equipment by saying that the problem of combustion control is as old as the burning of fuel. He was of the opinion that there is no basic difference between good automatic and good hand control of boilers and the combustion process. What the automatic lacks in prophetic and reasoning power, it more than makes up by keeping everlastingly at it and making accurately measured changes better than can be made by any but the most skilled operator.

From the viewpoint of automatic control, the speaker pointed out, there is a vast difference between the burning of solid fuels on grates and the burning of fuel in suspension, although the fundamentals are the same in both cases. The principal problem in the burning of solid fuels is to maintain a uniform fuel bed of the proper thickness over the entire grate area and supply air in proportion to the demand for steam. Burning fuel in suspension, the problem is to supply both air and fuel, intimately mixed, simultaneously in proportion to the demand for steam and maintain the relationship between fuel and air for best efficiency, considering also the life of the refractories. Steam pressure, said Mr. Bailey, is the invariable guide as to whether B.t.u. are being supplied to the boiler as fast as required by the load. He described an electrical system of centralized combustion control which is now in use in a number of plants in which the initial impulse is taken from the steam pressure and the relation between the fuel and air supply is adjusted on the steam-flow air-flow principle.

M. G. Benjamin was the second speaker, and although agreeing with Mr. Bailey, as did the other speakers, that the steam pressure should be depended upon to give the initial impulse to the control system, he said that means should also be provided to take into account all factors in the boiler operation. It was not enough to consider the outgoing steam, but the ingoing feed water must bear some relation to the steam demand. In his company's system of combustion control, he said, they preferred to use the most perfectly controllable drive for the auxiliaries, namely, the direct-current motor.

In this system the initial impulse is taken from a variation in steam pressure near the throttle valve by a master regulator. This impulse is transmitted to the field of exciting generators; one generator for the forced-draft fan, another for the stoker and a third for the induced-draft fan motors. A change in the exciting generator field strength changes the voltage of these machines, which in turn changes the excitation of the auxiliary motors and causes a change in speed corresponding to the load demand as reflected by the change in steam pressure. After this initial change takes place, a compensating device comes into operation which takes into account any inconsistencies in the boiler operation so as to maintain the most economical operation.

The question of how to prevent a hole in the fire when coal is burned on a grate was the center of considerable attention. Charles H. Smoot agreed with Mr. Bailey that the best way was not to allow a hole to get in the fire. As an example of how his system of automatic combustion control handled such a condition, he called attention to where on a 7-retort stoker 4 of the rams were disconnected and the boiler run for one hour, and the fire allowed to get in very bad condition. The retorts were again connected, and in twenty minutes the fire was back in good condition. During this period the boiler carried 150 per cent load.

Mr. Smoot was of the opinion that the control of pulverized fuel was not so difficult as for a stoker-fired boiler and the difference in the characteristics of the various drives for boiler auxiliaries were of small moment since these could be automatically compensated for in the control equipment. The automatic combustion-control equipment developed by his company, he explained, was of the mechanical type, as it was considered better suited to the class of men found in the average boiler room. This system takes its initial impulse from a variation in steam pressure corresponding to a change in load, which is transmitted pneumatically to the stoker, forced-draft and induced-draft fan drives, which change the fuel fed and air supply so as to maintain these in a constant relation regardless of the condition of the fire.

K. L. Martin said there are two kinds of power plants, the ordinary variety and the superpower type. In the former the boiler-room operators were responsible for the combustion-control apparatus, and in such cases the equipment had to be suited to the men. With the latter type experienced engineers were in charge of combustion, so that in such plants a more refined system of control was warranted. The speaker described two types of automatic systems of centralized combustion control, one a mechanical and the other an electrical.

The former is to meet the conditions in the plants where they do not have the class of attendants that are available in the large stations, where the latter type is more suitable. In these systems, as in those previously described, the initial impulse is taken from a change in steam pressure. This impulse is transmitted to a master regulator, which speeds up the forced-draft fan. In the mechanical type the change in pressure through the boiler is used to change the speed of the stoker and adjust the induced draft. In the electrical type the flow of air in the forced-draft duct adjusts the speed of the stoker and the pressure over the fire the induced draft.

Development of hydro-electric power on the lower Klamath River in northern California between the mouth of the Shasta River and the Pacific Ocean has been prevented for all time by the passage of initiative measure No. 11, sponsored by the California Fish and Game Commission. This bill was erronously announced in the Nov. 11 *Power* as probably having been defeated.

Society Affairs

The Chicago Section of the Association of Iron and Steel Electrical Engineers, will have as the subject for its Dec. 4 meeting, "Automatic Substations."

The Hartford Section of the A.S.M.E. will hold its Dec. 16 meeting at the Engineers Club. "What the Technical Press Means to Engineers," by President Low, A.S.M.E. and editor of *Power*, is the attraction for the evening.

The National Rivers and Harbors Congress will hold its twentieth convention at Washington, D. C., Dec. 10-11. This convention will be of interest to some readers because of the probable discussions that will take place on the pending government bills covering navigation and power of the St. Lawrence, Tennessee, Delaware, Columbia and other rivers of the country.

The Chicago Section of the A.S.M.E. and the **Western Society of Engineers** will hold a joint meeting at the rooms of the Western Society of Engineers, on the evening of Jan. 5, to discuss "Bearing Lubrication and Modern Methods of Applying Lubricants." The first paper on bearing lubrication is to be presented by J. A. Marland, technical manager of the Vacuum Oil Co. In the presentation, attention will be given to heavy and light bearings, low-speed and high-speed bearings, cement mill lubrication of Diesel engines, steam engines and steam and hydraulic turbines. The second paper on applying the lubricant will be presented by C. L. Sonon, factory manager of the Bassick Manufacturing Co. The use of grease will be discussed and modern methods of applying it, including the Alemite force-feed system.

Trade Catalogs

Una-Flow Engines—Mesta Machine Co., Pittsburgh, Pa. Bulletin U-2 gives curves and data as well as a description of this engine, built under the Stumpf patents.

Pumps—The Earle Gear & Machine Co., Wayne Junction, Philadelphia, Pa., Catalog describing centrifugal pumps of single-stage and multi-stage, is well illustrated and may be obtained on request.

Desuperheaters — Elliott Company, Jeannette, Pa. Bulletin N-6 is a recent catalog describing the design and operation of the desuperheaters manufactured by this company. Copies may be had on request.

Instruments—The Brown Instrument Co., Wayne and Windrim Aves., Philadelphia, Pa. Pamphlet describing pyrometers, automatic temperature controllers, thermometers, pressure gages, tachometers, Co_2 recorders, etc.

Conveyors — Conveyors Corp. of America, 326 West Madison St., Chicago, Ill. The catalog "The American High Duty Conveyor," describes a steam-jet ash conveyor, 9 in. dia., designed for handling ashes from power plants having high tonnages or operating under severe conditions.

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution Washington, D. C. Meeting at Washington, Dec. 29-Jan. 3.

The American Boiler Manufacturers Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Midwinter meeting at Cleveland on Feb. 12.

American Ceramic Society. R. C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Columbus, Ohio, Feb. 16-21.

The American Engineering Council. L. W. Wallace, 24 Jackson Place, Washington, D. C. Annual meeting at Washington, D. C., Jan. 16-17.

American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Annual meeting at Hotel Schenley, Pittsburgh, Pa., Dec. 3-6.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at New York City, Feb. 9-13.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 16-19.

American Petroleum Institute. R. L. Walsh, 15 West 44th St., New York City. Annual meeting at Texas Hotel, Fort Worth, Texas, Dec. 9-11.

American Society for Testing Materials. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 22-26.

American Society of Heating and Ventilating Engineers. F. C. Houghten, 33 West 29th St., New York City. Annual meeting at Boston, Jan. 28-30.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Que. Annual meeting at Montreal, Que., Jan. 27-29.

Exposition of Inventions. E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Building, 29 West 39th St., New York City, Dec. 8-13.

Illinois Society of Engineers. E. R. Tratman, Wheaton, Ill. Meeting at Chicago, Jan. 14-16.

Iowa Engineering Society. J. S. Dodds, Box 202, Ames, Iowa. Convention at Des Moines, Iowa, Jan. 27-30.

Kansas Engineering Society, Ernest Boyce, Lawrence, Kansas. Meeting at Lawrence, Kan., Dec. 10-12.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

National Marine Engineers Beneficial Association, Geo. A. Grubb, 313 Machinists Building, Washington, D. C. Convention at Hotel Franklin Sq., Washington, D. C., Jan. 19.

Society of Automotive Engineers. C. F. Clarkson, 29 West 39th St., New York City. Annual meeting at Detroit, Mich., Jan. 20-23.

West Virginia-Kentucky Association of Mine, Mechanical and Electrical Engineers. Herbert Smith, Huntington, W. Va. Fourth annual convention at Frederick Hotel, Huntington, W. Va., Dec. 12-13.

Western Association of Electrical Inspectors. G. M. Miller, 1304 South 7th St., Louisville, Ky. Annual convention at the Brown Hotel, Louisville, Ky., Jan. 27-28.

Lubrication—E. F. Houghton & Co., Philadelphia, Pa. "A Treatise on Steam Cylinder Lubrication," by the Houghton Research staff, has recently been issued by the company to describe and explain their Cyl-Tal lubricant.

Arches—M. N. Detrick Co., 140 South Dearborn St., Chicago, Ill. This is the eighth edition of the catalog "Detrick Arches," which describes typical and modern furnace settings equipped with suspended flat arches and sectional supported wall as applied to all types of boilers using pulverized coal or stoker equipment.

Fibre, Hard—Spaulding Fibre Co., Inc., Tonawanda, N. Y. A good catalog about the applications of this important material, hard fibre, has just been issued. Pictures of forms and interesting uses for the material are given. Bakerlite-Duresto and other fibres manufactured by the company are included in this catalog.

Steam Specialties—The Strong, Carlisle & Hammond Co., Cleveland, Ohio. The new catalog, No. 28, covers the traps, valves, controllers, governors, strainers, maintainers, regulators and other steam specialties manufactured by this company. It gives full descriptions of the equipment, and is well illustrated and furnished with price lists.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Nov. 17, 1924	Nov. 24, 1924
Pool 1	New York	$2.75	$3.00
Smokeless	Columbus	2.00	2.25
Clearfield	Boston	1.90	2.25
Somerset	Boston	2.05	2.35
Kanawha	Columbus	1.55	1.65
Hocking	Columbus	1.60	1.75
Pittsburgh No. 8	Cleveland	1.85	1.90
Franklin, Ill.	Chicago	2.35	2.50
Central, Ill.	Chicago	2.20	2.25
Ind. 4th Vein	Chicago	2.35	2.40
West Ky.	Louisville	1.60	1.75
S. E. Ky.	Louisville	1.60	1.75
Big Seam	Birmingham	1.70	1.90

FUEL OIL

New York—Nov. 26, light oil, tank-car lots; 28@34 deg. Baumé, 4¾c. per gal.; 36@40 deg., 5c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Nov. 18, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.85 per bbl.; 26@28 deg., $1.90 per bbl.; 28@30 deg., $1.95 per bbl.; 30@32 deg., $2 per bbl.; 32@36 deg., gas oil, 5c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Nov. 13, f.o.b. local refinery; 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.

Dallas—Nov. 22, f.o.b. local refinery, 26@30 deg., $1.15 per bbl.

Philadelphia—Nov. 22, 28@30 deg., $2.10@$2.15 per bbl.; 18@22 deg., $1.87½@$1.93¾; 13@16 deg., $1.75@$1.81½ per bbl.

Boston—Nov. 24, tank-car lots, f.o.b.; heavy oil, 12@14 deg. Baumé, 4½c. per gal.; light oil, 28@32 deg. Baumé, 5½c. per gal.

Cincinnati—Nov. 18, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5½c. per gal.

New Plant Construction

Ark., Cotton Plant—The City plans the construction of a new water works system, including pumps, etc., estimated cost $25,000. E. T. Archer & Co., New England Bldg., Kansas City, Mo., are engineers.

Ark., Little Rock—Little Rock Hotel Co., A. D. Gates, Pres., is having plans prepared for the construction of a 12 story hotel at 6th and Louisiana Sts., estimated cost $1,000,000. G. D. Barnett c/o Barnett, Hayes & Barnett, Century Bldg., St. Louis, Mo., is architect.

Ark., Little Rock—Newcomb Hotel Co., c/o J. N. Newcomb, Marion Hotel, awarded the contract for the construction of a 10 story hotel at Main and 7th Sts., to Ault & Burden, 117 West 2nd St.

Ark., Little Rock—Rector & Williams, Reigler Bldg., awarded the contract for the construction of a 10 story office building at 3rd and Spring Sts., to Herman-McCain Co., Reigler Bldg.

California—The Southern California Edison Co., 306 West 3rd St., Los Angeles has voted a budget to finance hydro-electric development on Big Creek San Joaquin river project, cost approximately $7,535,000; complete steam plants, now under construction $3,965,000; increase 220,000 volt transmission line facilities between Big Creek and Southern California, $1,500,000; extensions and betterments to distributing systems, $12,000,000.

Calif., Huntington Park—The City plans an election to vote $56,000 bonds to purchase present water system and to install additional equipment including 200,000 gal. elevated steel tank and tower, 100,000 gal reservoir, centrifugal pump, electric motor, etc.

Calif., Kirkwood—H. O. Harrison, c/o H. A. Kluegel, Balfour Bldg., San Francisco, Engr., is having plans prepared for irrigation of 522 acres, including installation of 2 centrifugal pumps operated by electric motors, capacity 1,800 g.p.m. each.

Calif., Los Angeles—Business Dist. Development Co., Merchants National Bank Bldg., is having plans prepared for the construction of a 6 story, 50 x 135 ft. hotel and store building on Wilcox Ave. C. F. Whittlesey, 6533 Hollywood Blvd., is architect.

Calif., Los Angeles—Ostepath Sanitarium Hospital, Inc., N. F. Sprague, Secy., Black Bldg., awarded the contract for the construction of a 5 story hospital at Temple and Hoover Sts., to Stromwell & Halperin, 1007 South Grand Ave.

Calif., Los Angeles—Peoples Mortgage Co., 405 South Hill St., is having preliminary plans prepared for the construction of an 8 story store and loft building including refrigeration system, and 2 electric elevators, at 5th and San Pedro Aves., estimated cost $500,000. G. M. Lindsey, 321 Laughton Bldg., is architect.

Calif., Merced—Merced Irrigation Dist., H. P. Sargent, Secy., will receive bids until Dec. 16 for two 48 x 60 in. slide gates for 265 ft. head, two 75 x 96 in. slide gates for 290 ft. head, two 96 in. inlet 290 ft. head needle type penstock valves, two 96 in. pivot valves, two 96 in. 290 ft. head needle type discharge valves, two 96 in. hydraulic balanced valves, for the Exchequer dam project and power house. R. V. Meikle is chief engineer.

Calif., Oakdale—The City is receiving bids for the construction of a pumping plant to be installed at well in south part of city. G. Macomber is engineer.

Fla., Jacksonville—Applebrook Co., D. P. Myerson, Jr., Pres., is having plans prepared for the construction of a 12 story hotel at 27-45 West Adams St., estimated cost $1,250,000. R. A. Benjamine, Bisbee Bldg., is architect.

Fla., Tampa—E. W. Hensley & A. E. Anderson, 305 Memorial Highway, plans the construction of a hotel at corner of Hyde Park Ave. and Platt St., estimated cost $800,000.

Ill., Jonesboro—The City, A. Berl, Clk., will receive bids until Dec. 5 for waterworks improvements, including pump house, 300 g.p.m. direct connected centrifugal pump and a 5 hp. motor, etc., estimated cost $40,000. W. A. Fuller Co., 1917 Railway Exchange, St. Louis, Mo., is engineer.

Ill., Springfield—Burns & McDonell Engineering Co., 402 Interstate Bldg., Kansas City, Mo., Engrs., will receive bids about Jan. 1, 1925 for the construction of a 10,000 gal. water filtration and softening plant and extensions to main power plant, estimated cost $500,000.

Ky., Glasgow—Glasgow Water Co. plans the construction of a new pumping station, including 50 to 60 hp. crude oil engine, triplex pump to deliver 600 g.p.m. water against static head of 230 ft., estimated cost $40,000. T. N. Bradford, is manager.

La., Monroe—Frost-Whitted Co., awarded the contract for the construction of a 5 story hotel to Central Constructing Co., Shreveport, estimated cost $600,000.

Me., Rumford—The Community Hospital Assn., plans the construction of a hospital, nurses' home and power house. Rogers & Dion, 142 Berkley St., Boston, Mass., are architects.

Mass., Beverly—The City and State plan the construction of a pumping station at Andrews Court, part of an extensive sewer project here and other nearby towns. H. Goodnough, Sewer Comn., Room 141 State House, is engineer.

Mass., Boston—370 Commonwealth Ave., Inc., 370 Commonwealth Ave., awarded the contract for the construction of a 9 story apartment hotel at Massachusetts and Commonwealth Aves., to Boyle Robertson Construction Co., Washington, D. C., estimated cost $1,000,000.

Mich., Detroit—Michigan Bell Telephone Co., Cass Ave., is having preliminary plans prepared for a 10 story addition to telephone and office building, including steam heating equipment. Smith, Hinchman & Grylls, 800 Marquette Bldg., are architects.

Mich., Grand Rapids—Blackmer Rotary Pump Co., Petoskey, plans the construction of a power plant and foundry in connection with the proposed plant on Century Ave., between Griggs and Plett Sts. Contract for the construction of a machine shop and office has been awarded to Owen, Ames, Kimball Co., Pearl St., estimated cost $100,000.

Mich., Pontiac—Jewett Radio & Phonograph Co., 79 South Saginaw St., is having plans prepared for the construction of a 2 story radio factory including 32 x 37 ft. steam heating plant, on Archard Lake Ave. Fisher Bros., 24 West Huron St., are architects.

Mo., Kansas City—Levy Bros. Meat & Provision Co., 22 Market St., plans the construction of 2 story retail store including two 25 ton ice manufacturing machines and specially constructed refrigerator room, estimated cost $150,000. Private plans.

Mo., St. Joseph—M. K. Goetz Brewing Co. awarded the contract for the construction of a 1 and 3 story cold storage plant to E. H. Lawhon Construction Co., St. Joseph, cost approximately $60,000.

Mo., St. Louis—Roxana Petroleum Corporation, Arcade Bldg., is having preliminary plans prepared for the construction of a 9 story office building on Locust St., at 13th St., estimated cost $1,000,000. Jamieson & Spearl, Arcade Bldg., are architects.

N. Y., Brooklyn—A. Cully, 470 Senator St., is in the market for 1 slip ring motor, 75 to 100 hp., 3 phase, 60 cycle.

N. Y., New York—The Dept. of Public Markets, E. O'Malley, Comr., Municipal Bldg., is having plans prepared for the construction of a 4 story refrigerating plant on Exterior St., estimated cost $325,000.

N. Y., New York—Elk-Freed Co., Inc., c/o J. Martine, 31 Union Sq., archt., is having plans prepared for the construction of a 20 story office building at 21st St. and Broadway.

O., Bexley—The Jennings-Lawrence Co., 511 Hartman Bldg., Columbus, Engrs., are preparing plans for a pumping station with capacity of 100 g.p.m.

O., Elyria—The Elyria Belting & Machinery Co., is in the market for boiler, locomotive type, 29 hp., 90 to 100 lbs. pressure.

Okla., Fairview—The City, O. T. Corwin, Clk., is in the market for 1 new 200 hp. Diesel oil engine generator set together with exciter and fuel tank.

Okla., Fort Sill—Office of the Constructing Quartermaster has rejected all bids for 3 boiler houses and heating plants for buildings No. 113, 115 and 123. New bids will be called for soon.

Okla., Hollis—The City voted a $100,000 bond issue for a new water supply system, including mains, pumps, reservoir, etc. Gant Baker Co., 1116 West Main St., Oklahoma City, is engineer.

Okla., Madill—The City is having preliminary plans prepared for the construction of a new electric light plant, including oil engine equipment, estimated cost $50,000. K. B. Carson, Madill, is engineer.

Ore., Molalla—Eastern & Western Lumber Co., Ft. of North 21st St., Portland, is building a new logging camp and saw mill and 20 miles of railroad by day labor, estimated cost $500,000. Owner is in the market for machinery, engines, boilers, etc. for 200,000 capacity mill, also rails and equipment. F. H. Ramson, Gen. Mgr.

Tex., Brownsville—Valley Light & Electric Co., has purchased a light and power plant at Raymondville and will enlarge plant and install additional engine, dynamo, etc. The company will also add a new power plant unit at Brownsville, and install engine, pumping unit, dynamo, etc.

Tex., Coleman—The City, E. P. Scarbrough, Mayor, voted $105,000 bonds for waterworks improvements, including larger pumping capacity, larger power house, etc.

Tex., Corsicana—Navaro County Hospital, A. P. Mayes, County Judge, Court House, will soon receive bids for the construction of a boiler and steam heating plant, including Kewanee boiler, etc., estimated cost $6,000.

Wash., Mt. Vernon—Dist. No. 22, Skagit County, has plans underway for reclaiming 9,000 acres of land, including the installation of pumping plant, irrigation lines and roads, estimated cost $1,300,000. The contract for the construction of an 8 mile dike has been awarded to Pacific Dredging & Construction Co., Atlaska Bldg., Seattle. Bonds have been voted for the project. R. H. Bailey, Mutual Life Bldg., Seattle, is engineer.

Wis., Fond du Lac—The Water Dept., J. Breister, Supt., will receive bids until Dec. 4 for addition to pumping station. J. E. Hennen, 74 South Main St., is engineer. Number and type of pumps not determined.

Wis., Janesville—Rock County voted $25,000 bonds for remodeling building at asylum and poor farm for refrigeration plant including machinery. A. Cullen, Supt. of Asylum. Engineer not selected.

Wis., Manitowoc—Aluminum Goods Mfg. Co., 15th and Franklin Sts., G. Vits, Pres., awarded the contract for the construction of a 7 story warehouse and manufacturing plant, also a power house, to W. W. Oeflein, Inc., 86 Michigan St., Milwaukee, estimated cost $350,000.

Wis., Onalaska—Onalaska Pickle & Canning Co., E. Johnson, Mgr., is having plans prepared for the construction of a 2 story cold storage warehouse, estimated cost $45,000. O. J. & R. E. Sorenson, 225 South 8th St., LaCrosse, are architects. Owner is in the market for refrigeration equipment.

Wis., Waupun—Water & Light Comn., R. Zimmermann, Clk., will receive bids until Dec. 4 for one single stage centrifugal pump, 500 g.p.m. capacity.

Ont., Toronto—Remington Typewriter Co., Ltd., 146 King St., W., plans the construction of a factory, estimated cost $200,000. Architect not selected. Owner is in the market for equipment including motors.

Que., Coaticook—The rate payers have approved the project and bids will soon be asked for the development of 1850 electric hp. under a 145 ft. head, utilizing the upper half of gorge on Coaticook River, also the construction of a dam and tunnelling through 1,500 ft. of rock to North Coaticook where power house will be erected, 2 hydro electric units of 125 hp. each, estimated cost $180,000. E. O. Baldwin is mayor.

Que., Montreal—P. R. DuTremblay, Drummond Apts., awarded the contract for the construction of a 13 story apartment house at Sherbrooke and Mount Aves., to Anglin Norcross, Victoria St., estimated cost $3,500,000.